CS-759

# FINAL REPORT ON THE DIGITAL AUDIO CAPTURE AND IDENTIFICATION SYSTEM (DACIS)

FOR THE REMOTE ENVIRONMENTAL SENSING PROGRAM

AUGUST 1998

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# REPORT DOCUMENTATION PAGE

*Form Approved OMB No. 074-0188*



| 1. AGENCY USE ONLY (Leave blank) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | August 1998 | Final Report |

**4. TITLE AND SUBTITLE**
Final Report on the Digital Audio Capture and Identification System (DACIS).
SERDP: Advanced Biotelemetry for Resource Management on Military Lands (CS-759) , Part II

**5. FUNDING NUMBERS**
N/A

**6. AUTHOR(S)**
Protagoras N. Cutchis

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Johns Hopkins University Applied Physics Laboratory

**8. PERFORMING ORGANIZATION REPORT NUMBER**
N/A

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
SERDP
901 North Stuart St. Suite 303
Arlington, VA 22203

**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
N/A

**11. SUPPLEMENTARY NOTES**



**12a. DISTRIBUTION / AVAILABILITY STATEMENT**
Approved for public release: distribution is unlimited.

**12b. DISTRIBUTION CODE**
A

**13. ABSTRACT *(Maximum 200 Words)***
The Digital Audio Capture and Recognition System (DACIS) is designed to be an animal mounted (eventually bird borne) system which records and analyzes animal noises automatically. While the DACIS is fairly complex, it is actually an advanced acoustic sensor from a system point of view. The goal of the prototype system is to be able to identify with a high degree of reliability 4 animal calls from a single or multiple species. A very limited number of tests were performed on the DACIS with four types of wolf calls that were named growls, howls, whines and barks. A threshold value of 17 was found to be optimal yielding no false positives and 25% false negatives I early testing. Later tests showed up to 50% false negatives but still no false positives with a threshold of 20 or lower.

**14. SUBJECT TERMS**
SERDP, DACIS, biotelemetry, biodiversity, natural resource management, wildlife

**15. NUMBER OF PAGES**
140

**16. PRICE CODE**
N/A

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| unclass | unclass | unclass | UL |

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*Please refer to:*
CMI-98-040

31 August 1998

***Institute for Advanced Science and Technology in Medicine***

To: WS Seegar

From: PN Cutchis, M. D.

Subject: Final Report on the DACIS (Digital Audio Capture and Identification System)

Enclosures:
(1) Schematics of DACIS Processor Board
(2) Assembly Language Software for DACIS unit
(3) BASIC Software for PC Communication/Test Software
(4) Raw and analyzed data from DACIS for wolf calls
(5) Article from September 1997 NASA conference on DACIS

## INTRODUCTION AND GENERAL DESCRIPTION OF THE DIGITAL AUDIO CAPTURE AND RECOGNITION SYSTEM (DACIS)

The DACIS system is designed to be an animal mounted (eventually bird borne) system which records and analyzes animal noises automatically. While the DACIS is fairly complex, it is actually an advanced acoustic sensor from a system point of view. The goal of the prototype system described here is to be able to identify with a high degree of reliability 4 animal calls from a single or multiple species. The system is based on an 8-bit MC68HC811 microprocessor that contains EEPROM, an 8-bit A/D converter and a serial interface, all of which are used in the DACIS design. The prototype board is 1.95" square and weighs 18.2 grams. This version incorporates a socket, which increase the size and weight of the board. The final design, which has been laid out, is 1.85" square and should weigh less than 15 grams.

The present design captures 5 seconds of audio at 6,000 samples per second to yield a theoretical high frequency capture of 3 kHz. The system then performs 10 digital filters on each of ten 0.5 second time epochs to yield a matrix of 100 time/frequency parameters. These parameters are then normalized to account for volume level differences and then compared to a stored table using a pattern-matching algorithm.

The DACIS unit, while in the listen mode, only has the microphone, 2-stage amplifier, and threshold comparator circuit operating. In this mode, the unit consumes only 900-1300 μA of current at 5 VDC. If the volume level exceeds a preset threshold (adjustable on the board), then the

processor is awoken from its STOP (low power) mode and starts the digital 5 second recording. While recording and performing the analysis, the DACIS system consumes approximately 16 mA and this analysis takes 17 minutes per animal call.

## SOFTWARE DESCRIPTION

The assembly language software for the DACIS includes subroutines that perform the following major tasks:

1) Interrupt trigger of processor
2) Digital 5 second recording
3) 10 frequency band digital band-pass filters
4) Subroutine for normalization of filter outputs
5) Pattern matching against four stored templates
6) Communication with Dahlgren furnished ARGOS PTT host microprocessor

The software for the DACIS system was written entirely in assembly language and the test software for the host PC was written in BASIC. The software initializes memory locations and other parameters and then executes the STOP command that halts all microprocessor functions including the oscillator for maximum power conservation. The IRQ (Interrupt ReQuest) line, which is pulled low by the comparator when the audio volume exceeds a preset threshold, awakens the processor from the stopped state. The processor then records 5 seconds of audio at 6,000 samples per second. Then, the software, in the routine DIGIFILT (for digital filter) performs 10 FIR (Finite Impulse Response) filters at frequencies from 250 Hz to 2500 Hz in 250 Hz increments. The filters are 23 stage. This number was determined from simulations run on a PC to obtain suitable fall off without too much filter overlap. The 10 filters are run on each of 10 time epochs which are approximately 0.5 seconds in length (the exact length is 0.512 seconds to ease software design).

After completing the digital filters, the 100 parameters obtained are normalized to compensate for differences in volume level during recording. The next routine is the pattern match routine which performs the least squares fit to the 100 template parameters for each of the four stored templates. The formula used is:

$$x = \sqrt{\frac{\sum \left(a_{ij} - c_{ij}\right)^2}{100}}$$

where $a_{ij}$ and $c_{ij}$ are the filter outputs and template parameters respectively. The last routine that was going to be implemented was simple threshold detection for positive identification of the calls. It was decided to not implement that routine (although it is coded into the DACIS processor) and instead to transfer all four correlation values from the above equation for each call to the Dahlgren unit.

There can be timing problems with missed bytes if the PC utilized is a very new fast processor. Adjusting timing loops in the PC code can compensate for this.

## HARDWARE DESCRIPTION

The design of the hardware is complete. The MC68HC11 microprocessor contains internal RAM (Random Access memory), EEPROM (Electrically Erasable Read Only Memory), a UART (Universal Asynchronous Receiver Transmitter) and A/D (Analog to Digital)converter subsystems on-chip which are used in this design.

A two-stage amplifier built from an LM358AM dual operational amplifier amplifies the microphone's signal. Then, the signal is fed into an LM339 voltage comparator. When the sound level exceeds a threshold, which is set by an on board trimmer potentiometer, the IRQ line of the processor is brought low and the processor awakens from its low power "sleep" state and starts recording. The memory is a 128K byte by 8 static RAM of which all 128K can be addressed in the present hardware. However, the present software only requires about 32K.

Two versions of the DACIS processor were laid out and 2 prototypes of one version were fabricated. One version has no socket for the microprocessor and the second version, which is slightly larger, has a socket. The sizes are 1.85" square and 1.95" square respectively. The version with the socket version has been fabricated since this version allows easy removal of the microprocessor for software changes.

## POWER SUPPLY REQUIREMENTS

The DACIS board requires regulated 5 VDC +/-500mV as there is no on board voltage regulation. The current consumption varies somewhat from unit to unit but is between 900 μA and 1250 μA during the listen period and 15 mA and 34 mA during the record and signal analysis periods. The DACIS system, other than audio "awakening" has no internal method to completely shut itself off. It shuts down all of its own internal timers while in the "stop" mode to save power and therefore has no reference of how much time has passed. Therefore, in the Dahlgren application, the Dahlgren unit, which does have a real-time clock, will be responsible for time keeping. The maximum number of calls to be analyzed over any set time period can be programmed by having the Dahlgren processor shut down power to the entire DACIS unit until further analyses are desired.

## DAHLGREN INTERFACE

The details of the Dahlgren interface were not confirmed until August of 1998. The interface functions as follows. There are 2 serial lines (one in each direction), 0-5 volts at 9,600 baud, 8 bits, 1 stop bit and no parity between the two processors. The DACIS will keep the transmit line at high impedance until it is given permission to transmit data (see below). There are 2

additional handshaking lines, again one in each direction between the two processors. After analyzing a call, the DACIS will raise its line high to signal the Dahlgren processor that it has data available for transfer. When it is ready, the Dahlgren processor will raise its line to the DACIS high signaling that it is prepared for data transfer. The DACIS will immediately enable the transmitter and await an ASCII "S" from the Dahlgren unit over the serial link. The DACIS will wait essentially forever in an infinite loop until it sees this "S" or an "R" for resend. The DACIS will then transfer 4 bytes that correspond to the four template matches. After transferring the data once, the DACIS will wait for about 0.5 seconds to see if an "R" or "S" is sent to request that the data be sent again. If the DACIS does not receive an "R" or "S" within the 0.5 seconds it will reset and wait to analyze the next call. If it does it will wait again for another 0.5 seconds. The unit can be kept in this mode, resending the same data forever if requests are continually sent within 0.5 second windows.

The last portion of the Dahlgren interface is that the Dahlgren processor will have control over the DACIS power lines so that if too many analyses are being conducted, the Dahlgren unit can shut down the DACIS board temporarily to save system battery power.

The wiring connections on the ribbon cable to the DACIS board are as follows:

| | |
|---|---|
| BLUE: | Ground |
| GREEN: | Dahlgren to DACIS control line |
| YELLOW: | DACIS to Dahlgren control line |
| ORANGE: | Serial data output |
| RED: | Serial data input |
| BROWN: | +5VDC |

## TRIGGER SOUND LEVEL ADJUSTMENTS

The gain of the two stage audio amplifier is fixed at a level that was found to be suitable for most anticipated wildlife environments. The goal was to obtain reasonable gain without the amplifier saturating. However, the trigger threshold is adjustable by adjusting a small trimmer potentiometer on the back (opposite side from the processor) of the board. The setting of this potentiometer is quite "touchy". All of the trimmers were set at APL during testing to a level that seemed appropriate. However, without actual field data to indicate most likely volume levels for a specific species, the level set at APL may need further adjustment. If the level is set to be too sensitive, the unit will trigger too frequently on spurious sounds. Therefore, it is recommended that the unit be set slightly to the less sensitive side of what may be perceived as optimum. The setting found at APL to be best yields a voltage of 1.5 volts at pin 4 of the LM339 comparator.

**TEST RESULTS**

A very limited number of tests were performed on the DACIS with four types of wolf calls that were named growls, howls, whines and barks. The howls and barks frequently blend together. This is one of several factors which indicate that from an acoustic standpoint, wolves appear not have been an "easy" first target animal for the DACIS system. Wolves were chosen because of the availability of acoustic data and because they are large enough to carry a large collar with the Dahlgren Argos/GPS unit.

The data were first analyzed on a PC in Excel with digital filter outputs transferred across a serial link from the DACIS. This was done so that actual wolf calls, as recorded through the DACIS microphone and recorded by its processor could be used. The threshold value, which can now be selected at the analysis station, can be moved up or down so as to reduce false positives or false negatives or the total error rate. As the spreadsheets show in Enclosure 4, a threshold value of 17 was found to be optimal yielding no false positives and 25% false negatives in early testing. Later tests showed up to 50% false negatives but still no false positives with a threshold of 20 or lower.

An additional analog data tape received in August 1998 provided few if any wolf calls of quality worthy of conducting additional testing. Therefore, after discussions with the sponsor, it was decided not to conduct further analyses. It was agreed upon to instead load the existing template parameters into the DACIS and to complete the software for the Dahlgren interface.

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**Internal Distribution:**

PN Cutchis (w/enclosures)
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CMI Files (w/enclosures)

# Enclosure 1
# Schematics of DACIS Processor Board

NOTES:

1 WHERE APPLICABLE, UNLESS OTHERWISE SPECIFIED:

ALL RESISTANCES ARE IN OHMS

ALL CAPACITANCES ARE IN FARADS

ALL VOLTAGES ARE DC

THE SYMBOL _ REPRESENTS A SPACE

⟹( ) SHEET TO SHEET REFERENCES

2 THE FOLLOWING ARE THE LAST REF DESIGNATIONS USED:

C13, MK1, R18, U8, Y1

3 THE FOLLOWING ARE UNUSED REF DESIGNATIONS:

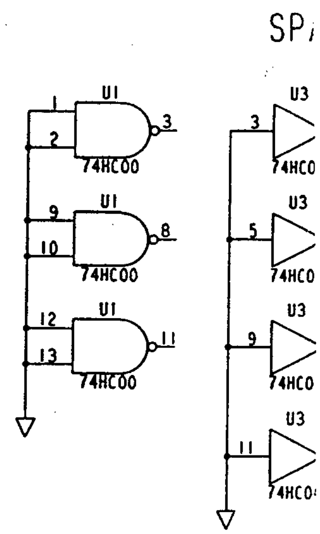
NONE

4 UNLESS SHOWN ON THE ACTUAL CIRCUITRY, ALL POWER CONNECTIONS FOR INTEGRATED CIRCUITS WILL BE REPRESENTED ON THE "IC POWER/GROUND CHART"

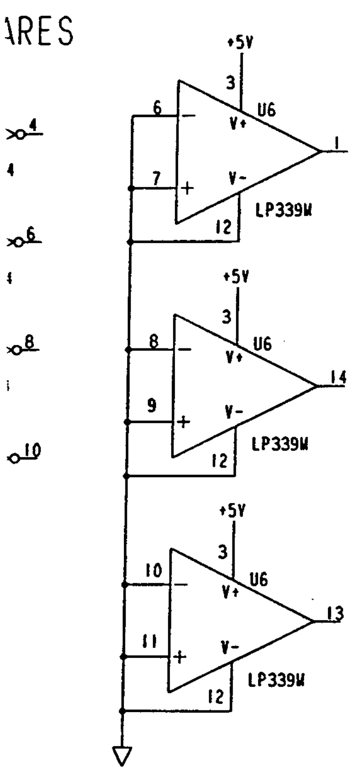
## IC POWER/GROUND CHART

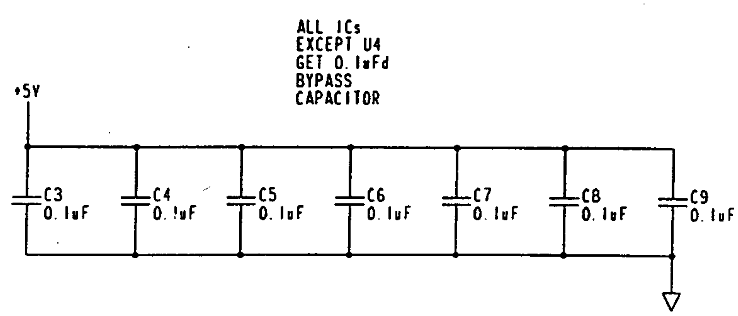
+5V

| +5V PIN | | REF NO | PART NO | GENERIC NO | | GND PIN |
|---|---|---|---|---|---|---|
| 14 | +V | U1 | MM74HC00M | 74HC00 | 6 | 7 |
| 14 | +V | U3 | MM74HC04M | 74HC04 | 6 | 7 |
| 20 | +V | U8 | MM74HC373WM | 74HC373 | 6 | 10 |
| | | U5 | LM358AM | LM358A | | |
| | | U6 | LP339M | LP339 | | |
| | | U7 | MC68HC811E2CFN | MC68HC811E2 | | |
| | | U4 | S-8054HN-CB-X | S-805 | | |
| 32 | +V | U2 | SRM20100LMT70 | SRM20100LMT70 | 6 | 16 |



5301-1851




BASIC

PARTS LIST

| | |
|---|---|
| DRAWN BY | PH CUTCHIS |
| DESIGNED | J.A. DAVIS |
| SYSTEM ENGR | PH CUTCHIS |
| PROGRAM | PH CUTCHIS |

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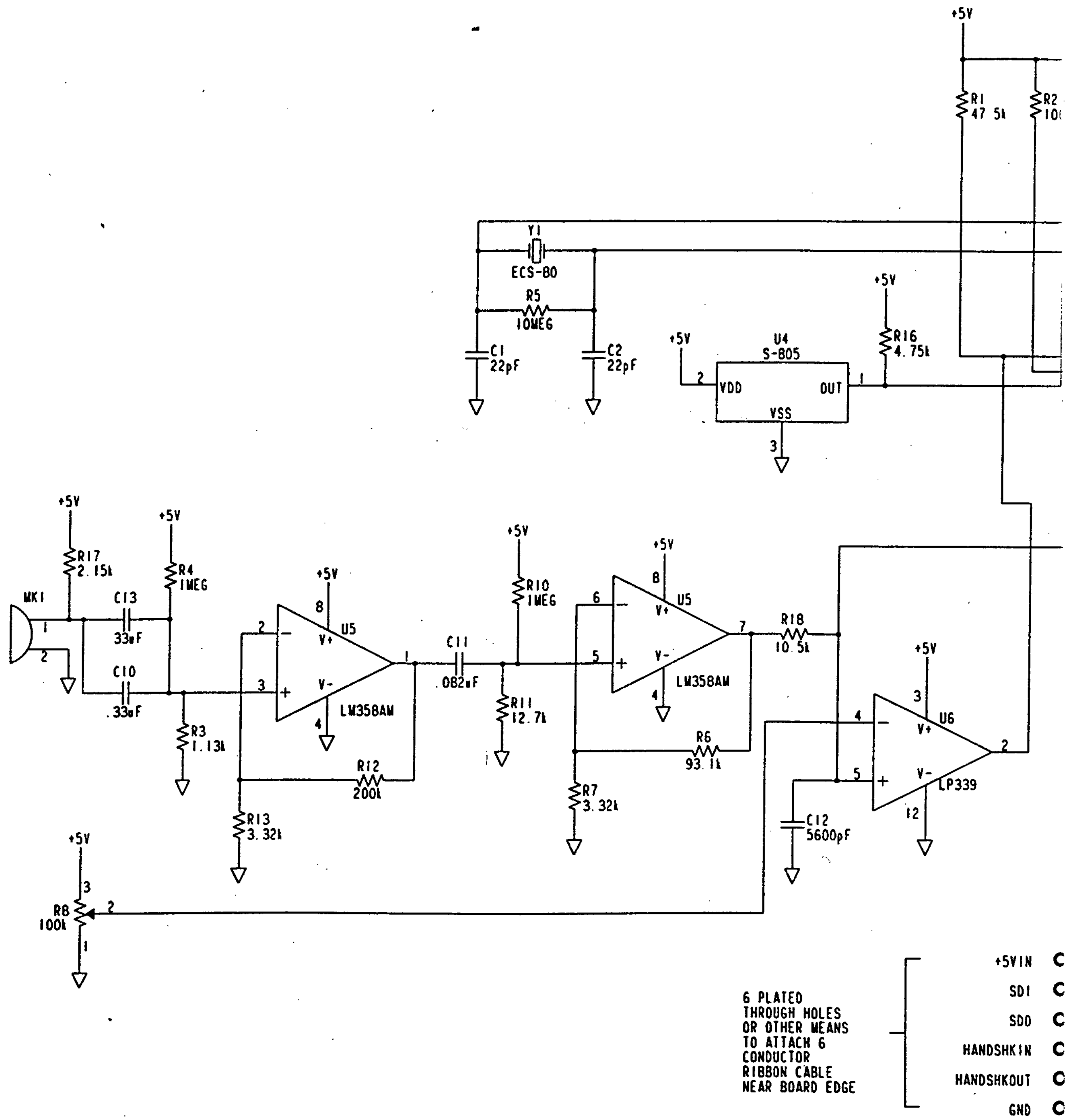
SCHEMATIC
TRIGGERED BIRD #2
AUDIO CAPTURE SYSTEM
WITH 128K MEMORY

| CAGE CODE | SIZE | DWG NO. | REV |
|---|---|---|---|
| 88898 | D | 5301-1851 | a |

SCALE NONE — SHEET 1 OF 2

MENTOR GRAPHICS V8.2

5301-1850



D

C

B

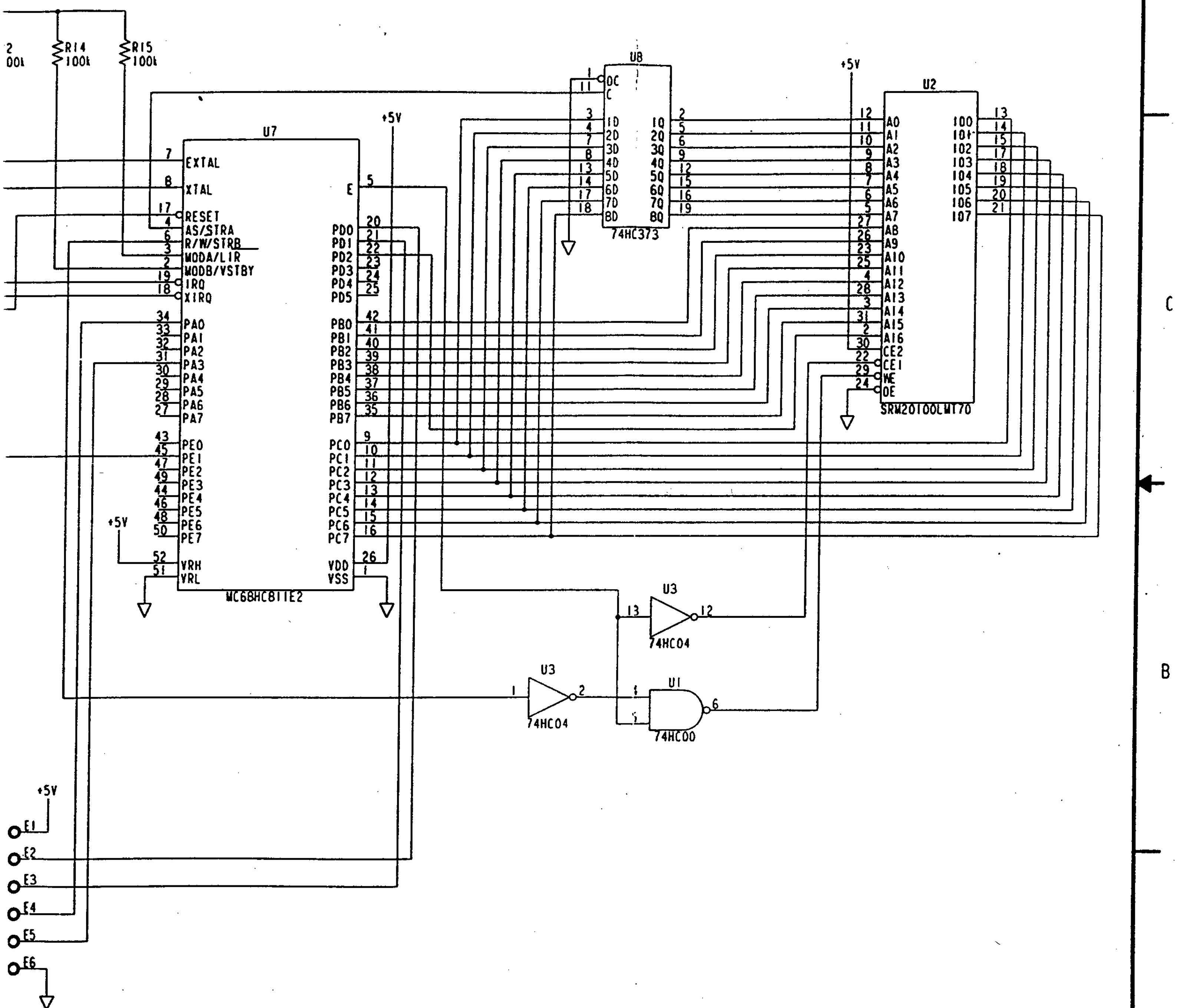
A

NOT ARCHIVED

7

6

5




| CAGE CODE | SIZE | DWG NO. | REV |
|---|---|---|---|
| 88898 | D | 5301-1851 | b |
| SCALE NONE | | DO NOT SCALE PRINT | SHEET 2 |

MENTOR GRAPHICS V8.2

5301-1850

**Enclosure 2**
**Assembly Language Software**
**For DACIS Processor**

```
        ; WOLF-MOUNTED DIGITAL AUDIO CAPTURE AND IDENTIFICATION
        ; SYSTEM (DACIS) FOR THE REST PROGRAM
        ; THIS PROGRAM IS DESIGNED FOR THE DAHLGREN INTERFACE
        ; **** ALL 10 DIGITAL FREQUENCY FILTERS WITH 10 TIME EPOCHS ***
        ;            WITH AUDIO CAPTURED THROUGH THE MICROPHONE
        ;
        ; VERSION: C:\BIRD97\WOLF987.ASM
        ;
        ; THIS VERSION UTILIZES A 128 KBYTE MEMORY (SRM20100LMT)
        ; & IMPLEMENTS THE LP339 COMPARATOR AUDIO THRESHOLD TRIGGER
        ; CREATED:       THURSDAY 8/27/98  2:25 PM
        ; LAST REVISION: THURSDAY 8/27/98  2:50 PM
        ; 1) CHANGED FROM IRQ TO XIRQ TO ALLOW STOP MODE USE 4/8/96
        ; 2) CHANGED TO OPERATE ON 4.9152 MHz XTAL (BAUD=00100001)
        ; 3) COMPLETED ASCII SUBROUTINE 7/18/96
        ; 4) REMAPPED INTERNAL ROM & RAM TO 8K AND 9K BOUNDARIES
        ; 5) CHANGED MEAN TO 50 TO ALLOW 5:1 DYNAMIC RANGE IN FILTER BANDS
        ; 6) REMOVED DATA TRANSFER CODE FROM DIGIFILT FOR FILTER OUTPUT 8/19/98
        ; 7) REMOVED DATA TRANSFER CODE FROM NORMALIZE 8/19/98
        ; 8) ADDED HSIN AND HSOUT  FOR DATA TRANSFER 8/19/98 (NO PA0 INTERRUPT)
        ; 9) DUMP ALL 8 BYTES OF MATCH DATA FOR TEST ONLY: ADDED 8/25/98
        ;     LAST REVIEWED: THURSDAY 8/27/98
                           DEFSEG  DIG,    START=0F800H
                           SEG     DIG
       ;-----------------------------------------------------------------------
       ;ROM ADDRESSES (REGISTERS ETC.)
=103D       INIT        EQU     $103D
=8000       PORTAADR    EQU     $8000
=8003       PORTCADR    EQU     PORTAADR+3
=8004       PORTBADR    EQU     PORTCADR+1
=8007       PORTCDDR    EQU     PORTBADR+3
=8008       PORTDADR    EQU     PORTCDDR+1
=8009       PORTDDDR    EQU     PORTDADR+1
=800E       TCNT        EQU     PORTDDDR+5
=8016       TOC1        EQU     TCNT+8
=8018       TOC2        EQU     TOC1+2
=8021       TCTL2       EQU     TOC2+9
=8022       TMSK1       EQU     TCTL2+1
=8023       TFLG1       EQU     TMSK1+1
```

```
=8024     TMSK2        EQU     TFLG1+1
=8026     PACTL        EQU     TMSK2+2
=802B     BAUD         EQU     PACTL+5
=802C     SCCR1        EQU     BAUD+1
=802D     SCCR2        EQU     SCCR1+1
=802E     SCSR         EQU     SCCR2+1
=802F     SCDR         EQU     SCSR+1
=8030     ADCTL        EQU     SCDR+1
=8031     ADR1         EQU     ADCTL+1
=8032     ADR2         EQU     ADR1+1
=8033     ADR3         EQU     ADR2+1
=8034     ADR4         EQU     ADR3+1
=8039     OPTION       EQU     ADR4+5
        ;-----------------------------------------------------------------
        ;RAM ADDRESSES
        ;VARIABLE         REL. ADD.    ABS. ADD.     FUNCTION
=9000     COUNT       EQU   $9000         ;0
=9001     TEMP1       EQU   COUNT+1       ;1
=9002     TEMP2       EQU   TEMP1+1       ;2
=9003     TEMP3       EQU   TEMP2+1       ;3
=9004     TIMINT      EQU   TEMP3+1       ;4&5        SAMPLE TIME INT IN uS
=9006     NUMINT      EQU   TIMINT+2      ;6          NUMBER OF PLAYBACK REPEATS
=9007     MEMPAGE     EQU   NUMINT+1      ;7          MEMPAGE=0 OR 1
=9008     ENDDATA     EQU   MEMPAGE+1     ;8 & 9      ADDRESS FOR END OF DATA
=900A     EPOCH       EQU   ENDDATA+2     ;10         ADDRESS FOR EPOCH # (1-10)
=900B     INSTRUCT    EQU   EPOCH+1       ;11         SINGLE BYTE INSTRUCTION
=900C     FILPAR      EQU   INSTRUCT+1    ;12&13      PARAMETER INDEX
=900E     AVERAGE     EQU   FILPAR+2      ;14&15      AVERAGE VALUE OF FILTER OUT
=9010     FILTAMP     EQU   AVERAGE+2     ;16-115     100 FILTER OUTPUTS
=9074     NUMCALL1    EQU   FILTAMP+100   ;116        NUMBER OF TYPE 1 CALLS
=9075     NUMCALL2    EQU   NUMCALL1+1    ;117        NUMBER OF TYPE 2 CALLS
=9076     NUMCALL3    EQU   NUMCALL2+1    ;118        NUMBER OF TYPE 3 CALLS
=9077     NUMCALL4    EQU   NUMCALL3+1    ;119        NUMBER OF TYPE 4 CALLS
=9078     FREQ        EQU   NUMCALL4+1    ;120        FILTER BEING USED (0-9)
=9079     FILTSTART   EQU   FREQ+1        ;121-122    START ADDRESS OF FILTER
=907B     SIGN        EQU   FILTSTART+2   ;123        BIT7=SIGN OF MULT RESULT
=907C     MEGAADDL    EQU   SIGN+1        ;124-125    MEGA ADDITTION REGIS-LOW
=907E     MEGAADDH    EQU   MEGAADDL+2    ;126-127    MEGA ADDITION REGIS-HIGH
=9080     PCLOADFLG   EQU   MEGAADDH+2    ;128        PC LOADING FLAG
```

```
=9081                 79 TESTADDRS  EQU   PCLOADFLG+1  ;129&130    TEST ADDRESS FOR PC DATA LOAD
=9083                 80 MACROADDL  EQU   TESTADDRS+2  ;131&132
=9085                 81 MACROADDH  EQU   MACROADDL+2  ;133&134
=9087                 82 STARTDATA  EQU   MACROADDH+2  ;135&136    START OF AUDIO DATA SEGMENT
=9089                 83 MATCHQUAL1 EQU   STARTDATA+2  ;137&138    QUALITY OF MATCH 1
=908B                 84 MATCHQUAL2 EQU   MATCHQUAL1+2 ;139&140    QUALITY OF MATCH 2
=908D                 85 MATCHQUAL3 EQU   MATCHQUAL2+2 ;141&142    QUALITY OF MATCH 3
=908F                 86 MATCHQUAL4 EQU   MATCHQUAL3+2 ;143&144    QUALITY OF MATCH 4
=9091                 87 STOREADDR  EQU   MATCHQUAL4+2 ;147&148    FILTER OUTPUT
=9093                 88 INITIAL    EQU   STOREADDR+2  ;149        0=INITIAL RECORD
=9094                 89 PATTERN    EQU   INITIAL+1    ;150-151    PATTERN NUMBER (0-3)
=9096                 90 CALLSDONE  EQU   PATTERN+2    ;152-153    NUMBER OF PATTERNS ANALYZED
=9098                 91 DAHLFLAG   EQU   CALLSDONE+2  ;154        FLAG FOR DAHLGREN DATA SENT
=F448                 92 MATCHDATA  EQU    -3000       ;           RAM MATCH DATA
                  93 ;-------------------------------------------------------------------
                  94 ; RESET AND INTERRUPT VECTORS
=FFFE                 95                  ORG     0FFFEH         ;RESET VECTOR
07FE& 0000&           96                  FDB     DIGREC
=FFF2                 97                  ORG     0FFF2H         ;IRQ VECTOR
07F2& 01D4&           98                  FDB     RECORD5
=FFD6                 99                  ORG     0FFD6H         ;RECEIVE DATA INTERUPT
07D6& 0079&          100                  FDB     DATAREC
=FFF6                101                  ORG     0FFF6H         ;SWI VECTOR
07F6& 01D4&          102                  FDB     RECORD5
=FFF8                103                  ORG     0FFF8H         ;ILLEGAL OPCODE TRAP
07F8& 0000&          104                  FDB     DIGREC
                     105 ;------------------------------------------------------------------
=F800                106                  ORG     0F800H
=0000&               107 DIGREC           EQU     $
0000& 0F             108                  SEI                   ;DISABLE INTERRUPTS
0001& 86 98          109                  LDAA    #98H          ;REMAP RAM AND REGISTERS
0003& B7 103D        110                  STAA    INIT          ;RAM STRT=$9000 REGS=$8000
0006& 86 00          111                  LDAA    #0            ;SET TIMER DIVIDER TO E/1
0008& B7 8024        112                  STAA    TMSK2         ;MUST BE DONE IN 1ST 64CLKS
000B& 8E 90FF        113                  LDS     #90FFH        ;LOAD STACK POINTER
000E& 86 88          114                  LDAA    #10001000B    ;CONFIGURE PORTA BITS 3 & 7
0010& B7 8026        115                  STAA    PACTL         ;AS OUTPUT TO D/A CONVERTER
0013& 86 04          116                  LDAA    #00000100B    ;CONFIGURE BITS D0&D1 AS INPUT
0015& B7 8009        117                  STAA    PORTDDDR      ;WILL BOTH BE HIGH IMPED FOR DAHLG
```

```
0018& B6 8039        118                LDAA    OPTION        ;USE EXTERN XTAL CLK & POWER-UP
001B& 8A 80          119                ORAA    #10000000B    ;A/D CONVERTER (BIT 7)
001D& B7 8039        120                STAA    OPTION
0020& 86 00          121                LDAA    #00000000B    ;SELECT 8 DATA BITS
0022& B7 802C        122                STAA    SCCR1
0025& B6 8008        123                LDAA    PORTDADR      ;SET TRANSMIT LINE HIGH=OFF
0028& 84 FB          124                ANDA    #11111011B    ;THIS OUTPUT IS INVERTED
002A& B7 8008        125                STAA    PORTDADR
002D& 86 21          126                LDAA    #00100001B    ;SET BAUD RATE TO 9600
002F& B7 802B        127                STAA    BAUD          ;FOR 4.9152 MHz CRYSTAL
0032& 86 FF          128                LDAA    #255          ;START A/D WARM-UP DELAY
0034& C6 FF          129 CNT2           LDAB    #255
0036& 5A             130 CNT1           DECB
0037& 26 FD          131                BNE     CNT1
0039& 4A             132                DECA
003A& 26 F8          133                BNE     CNT2          ;END A/D POWER-UP DELAY
003C& 86 05          134                LDAA    #5
003E& B7 9006        135                STAA    NUMINT
0041& CC 0000        136 NOTRIG         LDD     #0
0044& B7 8000        137                STAA    PORTAADR
0047& FD 9096        138                STD     CALLSDONE
004A& FD 9074        139                STD     NUMCALL1      ;ZERO OUT ALL CALLS IDENTIFIED
004D& FD 9076        140                STD     NUMCALL3
0050& FD 900C        141                STD     FILPAR
0053& B7 9080        142                STAA    PCLOADFLG
0056& B7 900A        143                STAA    EPOCH         ;START WITH EPOCH=0
0059& B7 9078        144                STAA    FREQ          ;ZERO OUT FILTER NUMBER
005C& B7 9093        145                STAA    INITIAL
005F& 86 01          146                LDAA    #00000001B    ;ENABLE PA0/IC3 INTERRUPT
0061& B7 8022        147                STAA    TMSK1
0064& B7 8021        148                STAA    TCTL2         ;CAPTURE RISING EDGES ONLY
0067& BD 046E&       149                JSR     FULLSEC
006A& BD 046E&       150                JSR     FULLSEC
                     151 ;-----------------------------------------------------------------------
006D& 8E 90FF        152 NEWSTART       LDS     #90FFH        ;RELOAD STACK
0070& 07             153                TPA
0071& 84 7F          154                ANDA    #01111111B    ;CLEAR "S" BIT TO ENABLE
0073& 06             155                TAP                   ;STOP MODE (TESTED 8/27/98=OK)
0074& 0E             156                CLI                   ;ALLOW INTERRUPTS NOW
```

```
0075& CF                              STOP
0076& 01                TRIGGER       NOP
0077& 20 F4                           BRA      NEWSTART      ;ALLOW MULTIPLE ANALYSES
                        ;-----------------------------------------------------------------------
                        ;MOST OF THE FOLLOWING COMMAND INTERPRETERS/DIRECTORS HAVE BEEN
                        ; COMMENTED OUT ON 8/20/98 AS THEY WERE FOR TEST USE ONLY
0079& 0F                DATAREC       SEI
007A& 86 FF                           LDAA     #0FFH         ;CLEAR FLAG TO PREVENT
007C& B7 8023                         STAA     TFLG1         ;CONTINUOUS INTERRUPTS
007F& B6 802E                         LDAA     SCSR          ;CLEAR RDRF FLAG
0082& B6 802F                         LDAA     SCDR
0085& B7 900B                         STAA     INSTRUCT
                        ;             LDAB     PCLOADFLG
                        ;             BEQ      INTERP
                        ;             JSR      INSINE2
                        ;             RTI
                        ;INTERP
                        ;             CMPA     #47H          ;CHECK SEND ID INSTRU="G"
                        ;             BNE      NEXTINT1
                        ;             JSR      ECHOID
                        ;             RTI
                        ;NEXTINT1     CMPA     #49H          ;"I" =INPUT SINE WAVE FROM PC
                        ;             BNE      NEXTINT2
                        ;             JSR      INSINE
                        ;             RTI
                        ;NEXTINT2     CMPA     #4FH          ;"O" = DUMP AMPLITUDE
                        ;             BNE      NEXTINT3
                        ;             JSR      DUMPAMP
                        ;             RTI
                        ;NEXTINT3     CMPA     #4EH          ;"N"=WATERFALL DUMP
                        ;             BNE      NEXTINT4
                        ;             JSR      CHCKNORM
                        ;             RTI
                        ;NEXTINT4     CMPA     #44H          ;"D"=DIGITAL FILTER
                        ;             BNE      NEXTINT5
                        ;             JMP      DIGIFILT
                        ;NEXTINT5     CMPA     #43H          ;"C"=CONFIRM DUMP
                        ;             BNE      NEXTINT6
                        ;             JSR      CONFIRM
```

```
;NEXTINT6       CMPA    #50H            ;"P"=CHECK MATCH
;               BNE     NEXTINT7
;               JSR     SENDMATCH
;MOVED THESE INTERPRETERS DIRECTLY INTO DAHLGREN ROUTINE
;               CMPA    #53H            ;"S"=SEND DATA
;               JSR     DAHLGREN
;               CMPA    #52H            ;"R"=RESEND DATA
;NEXTINT7       RTI
;-------------------------------------------------------------------
;THE FOLOWING ROUTINE ALLOWED DOWNLOADS OF SINE WAVE DATA FROM A PC
;TO TEST THE DIGITAL FILTER BANKS AND WAS COMMENTED OUT ON 8/24/98
;INSINE         LDAA    #1              ;MADE THIS A SUBROUTINE
;               STAA    PCLOADFLG       ;SO EXIT BY RTS ONLY!
;               LDD     #0
;               STD     TESTADDRS
;               RTS
;INSINE2        LDX     TESTADDRS
;               LDAA    INSTRUCT
;               STAA    0,X
;               INX
;               STX     TESTADDRS
;               CPX     #30720          ;CHECK FOR 30720 SAMPLES
;               BNE     ENDSINE
;               CLR     PCLOADFLG
;ENDSINE        RTS
;-------------------------------------------------------------------
;THE FOLLOWING SUBROUTINE WAS FOR TEST ONLY AND WAS
;COMMENTED OUT ON 8/24/98
;SENDMATCH      LDD     #MATCHQUAL1     ;SEND FIRST BYTE
;               JSR     ASCII
;               LDD     #MATCHQUAL1     ;SEND SECOND BYTE
;               JSR     ASCII
;               LDD     #0
;               STD     FILPAR
;               RTS
;-------------------------------------------------------------------
;THE FOLLOWING ROUTINE WAS FOR TEST PURPOSES ONLY AND WAS
;COMMENTED OUT ON 8/24/98
;CONFIRM        LDD     TESTADDRS
```

```
              ;                  CPD     #30720
              ;                  BEQ     SENDX
              ;                  LDD     #30750
              ;                  SUBD    TESTADDRS
              ;                  ADDB    #30H
              ;                  JSR     TRANBYTE2
              ;SENDX             LDAB    #58H          ;OUTPUT "X" FOR SUCCESSFUL LOAD
              ;                  JSR     TRANBYTE2
              ;                  RTS
              ;-------------------------------------------------------------------
              ;THE ABS SUBROUTINES ADDS THE FILTERED SAMPLE'S ABSOLUTE VALUES
0088& FC 907E ABS                LDD     MEGAADDH          ;IF H IS - SO IS TOTAL
008B& 2B 0B                      BMI     MAKEPLUS
008D& 27 02                      BEQ     CHECKLOW
008F& 20 19                      BRA     MACROADD
0091& FC 907C CHECKLOW           LDD     MEGAADDL
0094& 2B 02                      BMI     MAKEPLUS
0096& 20 12                      BRA     MACROADD
0098& CC 0000 MAKEPLUS           LDD     #0
009B& B3 907E                    SUBD    MEGAADDH
009E& FD 907E                    STD     MEGAADDH
00A1& CC 0000                    LDD     #0
00A4& B3 907C                    SUBD    MEGAADDL
00A7& FD 907C                    STD     MEGAADDL
00AA& FC 907C MACROADD           LDD     MEGAADDL
00AD& F3 9083                    ADDD    MACROADDL
00B0& 29 05                      BVS     MEGAINC2
00B2& FD 9083                    STD     MACROADDL
00B5& 20 0F                      BRA     ADDHI
00B7& 83 8000 MEGAINC2           SUBD    #-32768           ;STORE VALIDATED RESULT
00BA& FD 9083                    STD     MACROADDL
00BD& FC 9085                    LDD     MACROADDH
00C0& C3 0001                    ADDD    #1
00C3& FD 9085                    STD     MACROADDH
00C6& FC 907E ADDHI              LDD     MEGAADDH
00C9& F3 9085                    ADDD    MACROADDH
00CC& FD 9085                    STD     MACROADDH
00CF& CC 0000                    LDD     #0
00D2& FD 907E                    STD     MEGAADDH
```

```
00D5& FD 907C         274                STD    MEGAADDL
00D8& 39              275                RTS
                      276 ;------------------------------------------------------------------
00D9& CC 900F         277 CHCKNORM       LDD    #AVERAGE+1     ;SEND AVERAGE VALUE FIRST
00DC& BD 0105&        278                JSR    ASCII
00DF& FC 900C         279                LDD    FILPAR
00E2& 1A 83 0065      280                CPD    #101
00E6& 26 06           281                BNE    ENDROUT3
00E8& CC 0000         282                LDD    #0
00EB& FD 900C         283                STD    FILPAR
00EE& 39              284 ENDROUT3       RTS
                      285 ;------------------------------------------------------------------
00EF& CC F448         286 DUMPAMP        LDD    #MATCHDATA
00F2& BD 0105&        287                JSR    ASCII
00F5& FC 900C         288                LDD    FILPAR
00F8& 1A 83 000A      289                CPD    #10
00FC& 26 06           290                BNE    ENDROUT2
00FE& CC 0000         291                LDD    #0
0101& FD 900C         292                STD    FILPAR
0104& 39              293 ENDROUT2       RTS
                      294 ;--------------------------------------------------------------------
                      295 ;THE FOLLOWING ROUTINE WAS TO DUMP OUT THE STORED FILTER PARAMETERS
                      296 ;AND IS FOR TEST PURPOSES ONLY.  THIS ROUTINE WAS COMMENTED OUT
                      297 ;ON 8/24/98
                      298 ;DUMPPARAM      LDD    #FILT01WGHT
                      299 ;              JSR    ASCII
                      300 ;              LDD    FILPAR              ;PARAMETERS=10X23=230
                      301 ;              CPD    #230
                      302 ;              BNE    ENDROUT1
                      303 ;              LDD    #0
                      304 ;              STD    FILPAR
                      305 ;ENDROUT1       RTS
                      306 ;--------------------------------------------------------------------
0105& F3 900C         307 ASCII          ADDD   FILPAR
0108& 8F              308                XGDX
0109& FC 900C         309                LDD    FILPAR
010C& C3 0001         310                ADDD   #1
010F& FD 900C         311                STD    FILPAR
0112& E6 00           312 NEXTBYTE8      LDAB   0,X
```

```
0114& C1 00                      CMPB    #0
0116& 2D 07                      BLT     SENDNEG
0118& 86 00                      LDAA    #0
011A& FD 9001                    STD     TEMP1
011D& 20 22                      BRA     SENDNUM
011F& C6 2D          SENDNEG     LDAB    #45
0121& BD 0184&                   JSR     TRANBYTE2
0124& E6 00                      LDAB    0,X
0126& C1 80                      CMPB    #-128
0128& 26 0A                      BNE     OK128
012A& C6 31                      LDAB    #31H
012C& BD 0184&                   JSR     TRANBYTE2
012F& CC 001C                    LDD     #28
0132& 20 1E                      BRA     DIV10
0134& F7 9001        OK128       STAB    TEMP1
0137& C6 00                      LDAB    #0
0139& F0 9001                    SUBB    TEMP1
013C& 86 00                      LDAA    #0
013E& FD 9001                    STD     TEMP1          ;D=POSITIVE 1-128
0141& 1A 83 0064     SENDNUM     CPD     #100
0145& 2D 0B                      BLT     DIV10
0147& C6 31                      LDAB    #31H
0149& BD 0184&                   JSR     TRANBYTE2
014C& FC 9001                    LDD     TEMP1
014F& 83 0064                    SUBD    #100
0152& CE 000A        DIV10       LDX     #10
0155& 02                         IDIV
0156& FD 9001                    STD     TEMP1
0159& 8F                         XGDX                   ;QUOTIENT IN D
015A& C3 0030                    ADDD    #30H
015D& BD 0184&                   JSR     TRANBYTE2
0160& FC 9001                    LDD     TEMP1
0163& CB 30                      ADDB    #30H
0165& BD 0184&                   JSR     TRANBYTE2
0168& C6 20                      LDAB    #20H           ;SEND SPACE AFTER EACH
016A& BD 0184&                   JSR     TRANBYTE2      ;ASCII VALUE
016D& 39                         RTS
                     ;------------------------------------------------------------
016E& 18 CE 0000     ECHOID      LDY     #0
```

```
0172& CE 04EB&                         LDX     #ID
0175& E6 00        NEXTBYTE7           LDAB    0,X
0177& BD 0184&                         JSR     TRANBYTE2
017A& 08                               INX
017B& 18 08                            INY
017D& 18 8C 0011                       CPY     #17
0181& 26 F2                            BNE     NEXTBYTE7
0183& 39                               RTS
                   ;-------------------------------------------------------------------
0184& B6 802E      TRANBYTE2           LDAA    SCSR        ;CLEAR SCSR
0187& F7 802F                          STAB    SCDR        ;BYTE TO BE SENT LOADED
018A& B6 802E      CHECKTRANS          LDAA    SCSR
018D& 84 80                            ANDA    #10000000B
018F& 27 F9                            BEQ     CHECKTRANS
0191& 39                               RTS
                   ;-------------------------------------------------------------------
0192& 18 CE 0003   TRANSDELAY          LDY     #0003H      ;THIS ROUTINE PROVIDES 250mS
0196& CE 3DEB      NEXT31              LDX     #03DEBH     ;DELAY FOR TRANSMIT LINE
0199& 09           NEXT30              DEX
019A& 26 FD                            BNE     NEXT30
019C& 18 09                            DEY
019E& 26 F6                            BNE     NEXT31
01A0& 39                               RTS
                   ;-------------------------------------------------------------------
01A1& B6 8000      PORTTOGL            LDAA    PORTAADR
01A4& 88 FF                            EORA    #11111111B
01A6& B7 8000                          STAA    PORTAADR
01A9& B6 8008                          LDAA    PORTDADR
01AC& 88 FF                            EORA    #11111111B
01AE& B7 8008                          STAA    PORTDADR
01B1& 39                               RTS
                   ;-------------------------------------------------------------------
01B2& 86 80        FULLSEC2            LDAA    #10000000B      ;LIGHT FAR LED
01B4& B7 8000                          STAA    PORTAADR
01B7& 18 CE 000A                       LDY     #000AH
01BB& CE AACC      NEXTX11             LDX     #0AACCH
01BE& 09           NEXTX10             DEX
01BF& 26 FD                            BNE     NEXTX10
01C1& 18 09                            DEY
```

```
01C3& 26 F6                      BNE     NEXTX11
01C5& B6 8000                    LDAA    PORTAADR
01C8& 84 7F                      ANDA    #01111111B      ;TURN OFF FAR LED
01CA& B7 8000                    STAA    PORTAADR
01CD& BD 046E&                   JSR     FULLSEC         ;NO MORE INTERUPTS FOR
01D0& BD 046E&                   JSR     FULLSEC         ;ABOUT 2 SECONDS
01D3& 3B                         RTI
               ;-------------------------------------------------------------------
               ;THIS INTERRUPT HANDLER RECORDS 5 SECONDS OF AUDIO AFTER THRESHOLD
               ;IS REACHED
               ;THE FOLLOWING THREE LINES LIT A TEST LED DURING RECORDING
               ;AND WERE COMMENTED OUT ON 8/27/98
               ;                 LDAA    PORTAADR
               ;                 ORAA    #00001000B      ;LIGHT INDICATOR LED
               ;                 STAA    PORTAADR
01D4& B6 8008  RECORD5           LDAA    PORTDADR
01D7& 84 FB                      ANDA    #11111011B      ;ZERO OUT RAM A16=PD2
01D9& B7 8008                    STAA    PORTDADR
01DC& 86 01                      LDAA    #00000001B      ;SET FOR SINGLE CONVERSION
01DE& B7 8030                    STAA    ADCTL           ;START CONVERSIONS
01E1& CE 0000                    LDX     #0              ;START AT ADDRESS=0
01E4& 86 01    NEXTSAMP3         LDAA    #00000001B      ;2 CYC SET FOR SINGLE CONVERSION
01E6& B7 8030                    STAA    ADCTL           ;4 CYC START CONVERSIONS
               ;                                         SUBTOTAL = 6 CYCLES
01E9& B6 8030  CHECKAD2          LDAA    ADCTL           ;4CYC CHECK CONVERSION COMPLETE
01EC& 84 80                      ANDA    #10000000B      ;2CYC
01EE& 27 F9                      BEQ     CHECKAD2        ;3CYC
               ;                                         ABOVE CYC 9 CYCLES DON'T COUNT
01F0& B6 8031                    LDAA    ADR1            ;4 CYC
01F3& 2C 06                      BGE     SUB128          ;3 CYC CONVERT 0-255->-128 TO 127
               ;                                         ;SUBTOTAL CYCLES=13
01F5& 8B 7F                      ADDA    #127            ;2 CYC
01F7& 8B 01                      ADDA    #1              ;2 CYC
01F9& 20 06                      BRA     CONT522         ;3 CYC SUBTOTAL THIS ROUT=20
01FB& 80 7F    SUB128            SUBA    #127            ;2 CYC
01FD& 80 01                      SUBA    #1              ;2 CYC
01FF& 20 00                      BRA     CONT522         ;3 CYC SUBTOTAL THIS ROUT=20
0201& A7 00    CONT522           STAA    0,X             ;4 CYC SUBTOT=24
0203& 08                         INX                     ;3 CYC SUBTOT=27
```

```
0204& 8C 7800                           CPX     #30720          ;4 CYC SUBTOT=31
0207& 27 09                             BEQ     ENDREC          ;3 CYC SUBTOT=34  NEED 77CYC
0209& 86 07                             LDAA    #7              ;2 CYC SUBTOT=36
020B& 4A              MAINDELAY         DECA                    ;2 CYC
020C& 26 FD                             BNE     MAINDELAY       ;3 CYC LOOP=5 5x7=35 CYC ST=71
020E& 20 00                             BRA     ADDELAY         ;2 CYC SUBTOT=74
0210& 20 D2           ADDELAY           BRA     NEXTSAMP3       ;3 CYC SUBTOT=76
0212& B6 8000         ENDREC            LDAA    PORTAADR
0215& 84 F7                             ANDA    #11110111B
0217& B7 8000                           STAA    PORTAADR        ;TURN OFF LED
021A& BD 021E&                          JSR     DIGIFILT
021D& 3B                                RTI
                      ;-----------------------------------------------------------------
021E& CC 0000         DIGIFILT          LDD     #0
0221& FD 907C                           STD     MEGAADDL        ;ZERO OUT REGISTERS
0224& FD 907E                           STD     MEGAADDH        ;FOR DIGITAL FILTER SUMS
0227& FD 9083                           STD     MACROADDL
022A& FD 9085                           STD     MACROADDH
022D& B6 900A                           LDAA    EPOCH           ;LOAD ENDING ADDRESS OF DATA
0230& C6 0C                             LDAB    #12             ;
0232& 3D                                MUL                     ;D=0-108 SO B=0-108
0233& 17                                TBA
0234& 5F                                CLRB                    ;D=(0-108)*256= 0-27,648
0235& FD 9087                           STD     STARTDATA
0238& C3 0BE8                           ADDD    #3048           ;D=3071+(N*3072)-23
023B& FD 9008                           STD     ENDDATA
023E& 18 FE 9087                        LDY     STARTDATA       ;START SAMPLE DATA IN Y REG
0242& C6 17                             LDAB    #23             ;23 STAGES PER FILTER
0244& B6 9078                           LDAA    FREQ            ;FREQ= 0-9
0247& 3D                                MUL                     ;D=0 TO 207
0248& C3 04FC&                          ADDD    #FILT01WGHT
024B& FD 9079                           STD     FILTSTART       ;FILTER PARAMETER START IN D
024E& 8F                                XGDX                    ;X REG HAS FILT START
024F& 7F 9000                           CLR     COUNT
0252& A6 00           NEXTELEM          LDAA    0,X
0254& 18 E6 00                          LDAB    0,Y
0257& BD 0416&                          JSR     SIGNMULT
025A& BD 03E7&                          JSR     MEGAADD
025D& 7C 9000                           INC     COUNT
```

```
0260& B6 9000                         LDAA    COUNT
0263& 81 17                           CMPA    #23
0265& 27 05                           BEQ     SUMDATA       ;THIS DATA SAMPLE OF THE
0267& 08                              INX                   ;OUTPUT NOW TO BE SUMMED
0268& 18 08                           INY
026A& 20 E6                           BRA     NEXTELEM
026C& BD 0088&      SUMDATA           JSR     ABS
026F& 7F 9000                         CLR     COUNT
0272& 18 BC 9008                      CPY     ENDDATA
0276& 27 0C                           BEQ     RESETSAMP       ;DONE WITH THIS FILTER
0278& FE 9079                         LDX     FILTSTART     ;RESET FILTER ADDRESS
027B& 18 8F                           XGDY                  ;GET Y INTO D REG
027D& 83 0015                         SUBD    #21           ;0-22 SUB 21 INCS BY 1
0280& 18 8F                           XGDY                  ;NEW ADDRESS IN Y
0282& 20 CE                           BRA     NEXTELEM
0284& F6 900A       RESETSAMP         LDAB    EPOCH        ;STORE RESULT
0287& 86 0A                           LDAA    #10
0289& 3D                              MUL                  ;D=0-90->B=0-90
028A& FB 9078                         ADDB    FREQ         ;B=0-99
028D& C3 9010                         ADDD    #FILTAMP     ;ADD OFFSET
0290& FD 9091                         STD     STOREADDR
0293& FC 9085                         LDD     MACROADDH
0296& CE 0014                         LDX     #20          ;DIV BY 20 SHOULD KEEP ALL
0299& 02                              IDIV                 ;RESULTS<255 MAXIMUM!
029A& 8F                              XGDX                 ;GET QUOTIENT IN D REGISTER
029B& FE 9091                         LDX     STOREADDR
029E& E7 00                           STAB    0,X
                    ;-------------------------------------------------------------------
                    ;NEXT SECTION COMMENTED OUT ON 8/19/98 WAS FOR TEST DUMP OF
                    ;RAW DIGITAL FILTER OUTPUT DATA FOR TEST PURPOSES ONLY
                    ;NEXTBYTE1         LDD     #MACROADDL    ;OUTPUT 4 DATA BYTES
                    ;                 JSR     ASCII
                    ;                 LDD     FILPAR
                    ;                 CPD     #4
                    ;                 BEQ     RESFIL6
                    ;                 BRA     NEXTBYTE1
                    ;RESFIL6          LDD     #0
                    ;                 STD     FILPAR
                    ;-------------------------------------------------------------------
```

```
02A0& B6 9078                          LDAA    FREQ
02A3& 4C                               INCA
02A4& B7 9078                          STAA    FREQ
02A7& 81 0A                            CMPA    #10
02A9& 27 03                            BEQ     RESET815     ;DONE WITH ALL 10 FREQUENCIES
02AB& 7E 021E&                         JMP     DIGIFILT
02AE& 7F 9078         RESET815         CLR     FREQ         ;RESET FREQUENCY
02B1& 7C 900A                          INC     EPOCH
02B4& B6 900A                          LDAA    EPOCH
02B7& 81 0A                            CMPA    #10          ;REGULAR VALUES=0-9
02B9& 27 03                            BEQ     MAJORRES
02BB& 7E 021E&                         JMP     DIGIFILT
02BE& 7F 900A         MAJORRES         CLR     EPOCH
02C1& BD 02FC&                         JSR     NORMALIZE    ;NORMALIZE DATA
02C4& BD 034C&                         JSR     MATCH        ;CALCULATED CORELLATIONS
                      ;SKIP MATCH DECISION IN "FINAL" SUBROUTINE AND INSTEAD
                      ;SEND ALL FOUR CORELLATION COEFFICIENTS TO THE DAHLGREN UNIT
                      ;                JSR     FINAL        ;DO FINAL ANALYSIS AND STORE
02C7& BD 047D&                         JSR     DAHLGREN     ;AWAIT TRANSFER OPPORTUNITY
02CA& 39                               RTS
                      ;-----------------------------------------------------------------------
                      ;AS OF AUGUST, 1998, THIS ROUTINE WILL NOT BE USED.  ALL FOUR
                      ;CORRELATION VALUES WILL BE SENT OUT TO THE DAHLGREN PROCESSOR
02CB& FC 9089         FINAL            LDD     MATCHQUAL1   ;DIFF=0 TO 25,600 (100*256)
02CE& 1A B3 0771&                      CPD     THRESHOLD
02D2& 2E 03                            BGT     CHECK2
02D4& 7C 9074                          INC     NUMCALL1
02D7& FC 908B         CHECK2           LDD     MATCHQUAL2
02DA& 1A B3 0771&                      CPD     THRESHOLD
02DE& 2E 03                            BGT     CHECK3
02E0& 7C 9075                          INC     NUMCALL2
02E3& FC 908D         CHECK3           LDD     MATCHQUAL3
02E6& 1A B3 0771&                      CPD     THRESHOLD
02EA& 2E 03                            BGT     CHECK4
02EC& 7C 9076                          INC     NUMCALL3
02EF& FC 908F         CHECK4           LDD     MATCHQUAL4
02F2& 1A B3 0771&                      CPD     THRESHOLD
02F6& 2E 03                            BGT     DONEFINL
02F8& 7C 9077                          INC     NUMCALL4
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```
02FB& 39           DONEFINL       RTS
                   ;-----------------------------------------------------------------
                   ;SET AVERAGE VALUE TO 38 BY MULTIPLYING ALL VALUES BY C=38/AVERAGE
                   ;NOTE: AVERAGE OF 50 CAUSES PROBLEMS WITH DYNAMIC RANGE OF FILTER OUTPTS
02FC& CC 0000      NORMALIZE      LDD    #0
02FF& B7 9000                     STAA   COUNT
0302& FD 907C                     STD    MEGAADDL
0305& FD 907E                     STD    MEGAADDH
0308& CE 9010                     LDX    #FILTAMP
030B& 86 00        SUMMORE        LDAA   #0
030D& E6 00                       LDAB   0,X           ;VALUE= 0-256 IN D REG
030F& FD 9001                     STD    TEMP1
0312& BD 03E7&                    JSR    MEGAADD
0315& 08                          INX
0316& 7C 9000                     INC    COUNT
0319& B6 9000                     LDAA   COUNT
031C& 81 64                       CMPA   #100
031E& 26 EB                       BNE    SUMMORE
0320& FC 907C                     LDD    MEGAADDL      ;VALUE=0-25,600 (100X256)
0323& CE 0064                     LDX    #100          ;AVERAGE=(50*100)/100
0326& 02                          IDIV                 ;X REG=0-256
0327& FF 900E                     STX    AVERAGE       ;STORE AVERAGE
032A& 7F 9000                     CLR    COUNT
032D& 18 CE 9010                  LDY    #FILTAMP
0331& 18 A6 00     MORENORM       LDAA   0,Y           ;D REG NOW HAS VALUE X 256
0334& C6 26                       LDAB   #38           ;AIM FOR AVERAGE=38
0336& 3D                          MUL                  ;D REG NOW HAS + VALUE X 38
0337& FE 900E                     LDX    AVERAGE       ;NOW HAS 0 TO 32,768
033A& 02                          IDIV                 ;QUOTIENT IN X REG=0-256
033B& 8F                          XGDX                 ;QUOTIENT IN D
033C& 18 E7 00                    STAB   0,Y           ;STORE NORMALIZED VALUE
033F& 18 08                       INY
0341& 7C 9000                     INC    COUNT
0344& B6 9000                     LDAA   COUNT
0347& 81 64                       CMPA   #100
0349& 26 E6                       BNE    MORENORM
                   ;-----------------------------------------------------------------
                   ;THE FOLLOWING SECTION WAS COMMENTED OUT ON 8/19/98
                   ;THIS SECTION HAD TRANSFERRED THE NORMALIZED FILTER OUPUTS TO THE
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                   586 ;PC AND WAS FOR TEST PURPOSES ONLY
                   587 ;OUTNORM             JSR     FULLSEC        ;ONE SEC DELAY BETWEEN BYTES
                   588 ;                    LDD     #FILTAMP       ;ADDRESS=FILPAR+#FILTAMP
                   589 ;                    JSR     ASCII          ;SENT BY ASCII ROUTINE
                   590 ;                    LDAB    #20H
                   591 ;                    JSR     TRANBYTE2      ;SEND A SPACE
                   592 ;                    LDD     FILPAR
                   593 ;                    CPD     #100           ;CHECK FOR 100 PARAMETERS
                   594 ;                    BEQ     ENDNORM        ;SENT
                   595 ;                    BRA     OUTNORM
                   596 ;ENDNORM             LDD     #0
                   597 ;                    STD     FILPAR
034B& 39           598                      RTS
                   599 ;-----------------------------------------------------------------------
                   600 ;THIS ROUTINE WILL DO THE PATTERN MATCH
                   601 ;STORES ALL 8 BYTES OF MATCHQUAL DATA
034C& 7F 9000      602 MATCH                CLR     COUNT
034F& CC 0000      603                      LDD     #0
0352& FD 9094      604                      STD     PATTERN
0355& FD 907C      605                      STD     MEGAADDL
0358& FD 907E      606                      STD     MEGAADDH
035B& 18 CE 05E1&  607                      LDY     #MATCHEPOCH1T1  ;START OF TEMPLATE DATA
035F& CE 9010      608 SUMMER1              LDX     #FILTAMP       ;START OF NORMALIZED FILTER
0362& 18 E6 00     609 SUMPAT               LDAB    0,Y            ;TEMPLATE DATA INTO LOW BYTE
0365& 86 00        610                      LDAA    #0             ;ZERO OUT HIGH BYTE
0367& FD 9001      611                      STD     TEMP1
036A& E6 00        612                      LDAB    0,X            ;OUTPUT DATA INTO LOW BYTE
036C& 86 00        613                      LDAA    #0             ;ZERO OUT HIGH BYTE
036E& B3 9001      614                      SUBD    TEMP1          ;RESULT IN D REG
0371& FD 9001      615                      STD     TEMP1          ;STORE RESULT NOW
0374& 2B 02        616                      BMI     PLUSIT
0376& 20 09        617                      BRA     ADDIT
0378& CC 0000      618 PLUSIT               LDD     #0             ;NEGATE RESULT
037B& B3 9001      619                      SUBD    TEMP1          ;SO THAT ITS ALWAYS POS.
037E& FD 9001      620                      STD     TEMP1
0381& B6 9002      621 ADDIT                LDAA    TEMP2          ;LOW BYTE (0-255)
0384& F6 9002      622                      LDAB    TEMP2          ;LOW BYTE (0-255)
0387& 3D           623                      MUL
0388& FD 9001      624                      STD     TEMP1          ;STORE SQUARED RESULT
```

```
038B& BD 03E7&                  JSR     MEGAADD
038E& 7C 9000                   INC     COUNT
0391& 08                        INX
0392& 18 08                     INY
0394& B6 9000                   LDAA    COUNT
0397& 81 64                     CMPA    #100
0399& 27 02                     BEQ     NEXTPATT
039B& 20 C5                     BRA     SUMPAT
039D& 7F 9000       NEXTPATT    CLR     COUNT           ;SUM=0-25,500=>MEGAADDL
03A0& FC 907C                   LDD     MEGAADDL
03A3& CE 0064                   LDX     #100            ;AVERAGE=0-255
03A6& 02                        IDIV
03A7& 8F                        XGDX                    ;PLACE RESULT INTO D REG
03A8& FD 907C                   STD     MEGAADDL
03AB& FC 907E                   LDD     MEGAADDH
03AE& CE 0064                   LDX     #100
03B1& 02                        IDIV
03B2& 8F                        XGDX
03B3& FD 907E                   STD     MEGAADDH
03B6& CC 9089       STOREMATCH  LDD     #MATCHQUAL1
03B9& F3 9094                   ADDD    PATTERN         ;CORRECT ADDRESS IN D REG
03BC& F3 9094                   ADDD    PATTERN         ;2 BYTES PER MATCH
03BF& 8F                        XGDX                    ;CORRECT ADDRESS INTO X
03C0& FC 907E                   LDD     MEGAADDH
03C3& E7 00                     STAB    0,X             ;STORE LOW BYTE
03C5& 08                        INX
03C6& FC 907C                   LDD     MEGAADDL
03C9& E7 00                     STAB    0,X             ;STORE LOW BYTE
03CB& FC 9094                   LDD     PATTERN
03CE& C3 0001                   ADDD    #1
03D1& FD 9094                   STD     PATTERN
03D4& 1A 83 0004                CPD     #4
03D8& 27 0C                     BEQ     ENDMATCH
03DA& CC 0000                   LDD     #0
03DD& FD 907C                   STD     MEGAADDL
03E0& FD 907E                   STD     MEGAADDH
03E3& 7E 035F&                  JMP     SUMMER1         ;DO NEXT PATTERN
03E6& 39            ENDMATCH    RTS
                    ;---------------------------------------------------------------------
```

```
03E7& FC 9001        664 MEGAADD       LDD    TEMP1
03EA& F3 907C        665               ADDD   MEGAADDL
03ED& 29 04          666               BVS    MEGAINC
03EF& FD 907C        667               STD    MEGAADDL
03F2& 39             668               RTS
03F3& 2B 11          669 MEGAINC       BMI    FLIPIT1          ;RESULT WAS+/LOOKS -
03F5& 83 8000        670               SUBD   #-32768          ;STORE VALIDATED RESULT
03F8& FD 907C        671               STD    MEGAADDL
03FB& FC 907E        672               LDD    MEGAADDH
03FE& 83 0001        673               SUBD   #1
0401& FD 907E        674               STD    MEGAADDH
0404& 20 0F          675               BRA    ENDMEG
0406& 83 8000        676 FLIPIT1       SUBD   #-32768
0409& FD 907C        677               STD    MEGAADDL
040C& FC 907E        678               LDD    MEGAADDH
040F& C3 0001        679               ADDD   #1
0412& FD 907E        680               STD    MEGAADDH
0415& 39             681 ENDMEG        RTS
                     682 ;---------------------------------------------------------------------
0416& B7 9001        683 SIGNMULT      STAA   TEMP1
0419& F7 9002        684               STAB   TEMP2
041C& F8 9001        685               EORB   TEMP1
041F& C4 80          686               ANDB   #10000000B
0421& F7 907B        687               STAB   SIGN
0424& F6 9001        688               LDAB   TEMP1
0427& 2B 07          689               BMI    NEGATE
0429& F6 9002        690 TESTIT2       LDAB   TEMP2
042C& 2B 15          691               BMI    NEGATE1
042E& 20 24          692               BRA    MULT1
0430& C1 80          693 NEGATE        CMPB   #-128
0432& 26 07          694               BNE    GOON81
0434& 86 7F          695               LDAA   #127
0436& B7 9001        696               STAA   TEMP1
0439& 20 EE          697               BRA    TESTIT2
043B& 86 00          698 GOON81        LDAA   #0
043D& 10             699               SBA                    ;RESULT ACCUM A
043E& B7 9001        700               STAA   TEMP1
0441& 20 E6          701               BRA    TESTIT2
0443& C1 80          702 NEGATE1       CMPB   #-128
```

```
0445& 26 07                           BNE     GOON81A
0447& 86 7F                           LDAA    #127
0449& B7 9002                         STAA    TEMP2
044C& 20 06                           BRA     MULT1
044E& 86 00         GOON81A           LDAA    #0
0450& 10                              SBA
0451& B7 9002                         STAA    TEMP2
0454& B6 9001       MULT1             LDAA    TEMP1          ;0-127
0457& F6 9002                         LDAB    TEMP2          ;0-127
045A& 3D                              MUL                    ;0-16,129
045B& FD 9001                         STD     TEMP1
045E& B6 907B                         LDAA    SIGN
0461& 26 01                           BNE     NEGATEF
0463& 39                              RTS
0464& CC 0000       NEGATEF           LDD     #0
0467& B3 9001                         SUBD    TEMP1
046A& FD 9001                         STD     TEMP1
046D& 39                              RTS
                    ;------------------------------------------------------------------
046E& 18 CE 000A    FULLSEC           LDY         #000AH
0472& CE AACC       NEXT11            LDX         #0AACCH
0475& 09            NEXT10            DEX
0476& 26 FD                           BNE         NEXT10
0478& 18 09                           DEY
047A& 26 F6                           BNE         NEXT11
047C& 39                              RTS
                    ;----------------------------------------------------------------------
                    ;THIS ROUTINE SENDS THE DATA TO THE DAHLGREN PROCESSOR UPON REQUEST
                    ;1) IT IS EXECUTED AS AN INFINITE LOOP AFTER AN AUDIO ANALYSIS
                    ;2) IT FIRST CHECKS PA0 (HANDSHAKE IN) TO SEE IF IT IS HIGH
                    ;3) IF IT IS HIGH, THE DACIS ENABLES THE SERIAL OUPUT LINE
                    ;4) THE DACIS THEN WAITS AND LOOKS FOR AN "S" (SEND DATA)
                    ;5) THE DACIS THEN SENDS THE FOUR SERIAL SINGLE BYTE VALUES CORRESPONDING
                    ;   TO THE FOUR TEMPLATE CORRELATIONS FOR THIS WOLF CALL
                    ;6) THE DACIS THEN LOOPS FOR APPROXIMATELY ONE HALF SECOND CHECKING TO
                    ;   SEE IF THE DAHLGREN PROCESSOR HAS SENT AN "R" FOR RESEND THE DATA
                    ;7) AFTER THE ONE SECOND PASSES, THE ROUTINE RESETS COUNTERS AND
                    ;   EXECUTES AN RTI
                    ;8) THIS ROUTINE MODIFIED TO SEND ALL 8 BYTES OF MATCH DATA
```

```
047D& 7F 9098       DAHLGREN      CLR    DAHLFLAG        ;CLEAR DAHLGREN FLAG
0480& B6 8000                     LDAA   PORTAADR        ;UNTIL DAT SENT ONCE
0483& 8A 08                       ORAA   #00001000B      ;SET PA3 HIGH
0485& B7 8000                     STAA   PORTAADR
0488& B6 8000       DAHLGREN2     LDAA   PORTAADR
048B& 84 01                       ANDA   #00000001B      ;CHECK BIT PA0
048D& 26 02                       BNE    SENDDAHL1
048F& 20 F7                       BRA    DAHLGREN2       ;CHECK HNDSHK IN AGAIN
0491& 86 0C         SENDDAHL1     LDAA   #00001100B      ;ENABLE TRANS/REC
0493& B7 802D                     STAA   SCCR2           ;NO TRANS. OR REC. INT.
0496& CE 6C81       SENDDAHL2     LDX    #27777        ;27,777 X 18uS =0.5 SEC
0499& B6 802E       SENDDAHL3     LDAA   SCSR          ;4 CYC
049C& 84 20                       ANDA   #00100000B    ;2 CYC  CHECK RECEIVE DATA
049E& 26 0C                       BNE    CHECKCOMM1    ;3 CYC  REGISTER FULL
04A0& 09                          DEX                  ;3 CYC
04A1& 27 02                       BEQ    CHECKFLAG1    ;3 CYC
04A3& 20 F4                       BRA    SENDDAHL3     ;3 CYC TRY AGAIN
                    ; TOTAL= 18 CYCLES
04A5& B6 9098       CHECKFLAG1    LDAA   DAHLFLAG        ;CHECK FOR DATA SENT ONCE
04A8& 26 2E                       BNE    ENDAHLGREN      ;QUIT IF SENT ONCE
04AA& 20 EA                       BRA    SENDDAHL2       ;MUST TRANSMIT ONCE!
04AC& B6 802F       CHECKCOMM1    LDAA   SCDR            ;GET DATA INTO A REG
04AF& F6 802E                     LDAB   SCSR            ;CLEAR RDRF FLAG
04B2& 81 53                       CMPA   #53H            ;"S"=SEND DATA
04B4& 27 06                       BEQ    SEND4BYTES
04B6& 81 52                       CMPA   #52H            ;"R"=RESEND DATA
04B8& 27 02                       BEQ    SEND4BYTES
04BA& 20 DA                       BRA    SENDDAHL2       ;CONTINUE LOOKING
04BC& 86 01         SEND4BYTES    LDAA   #1
04BE& B7 9098                     STAA   DAHLFLAG
04C1& 18 CE 0004                  LDY    #4
04C5& CE 9089                     LDX    #MATCHQUAL1     ;FIRST MATCH BYTE
04C8& 08                          INX
04C9& E6 00         SNDMORE1      LDAB   0,X             ;LOAD DATA INTO B REG
04CB& BD 0184&                    JSR    TRANBYTE2       ;SEND DATA
04CE& 08                          INX
04CF& 08                          INX
04D0& 18 09                       DEY
04D2& 27 C2                       BEQ    SENDDAHL2       ;DO IT AGAIN?
```

```
04D4& 20 F3                                BRA    SNDMORE1
04D6& 20 00                                BRA    ENDAHLGREN
04D8& 86 00            ENDAHLGREN          LDAA   #00000000B     ;DISABLE TRANS/REC
04DA& B7 802D                              STAA   SCCR2          ;NO TRANS. OR REC. INT.
04DD& 7F 9098                              CLR    DAHLFLAG       ;NOT NEEDED HERE BUT CLR
04E0& B6 8000                              LDAA   PORTAADR       ;ANYWAY
04E3& 84 F7                                ANDA   #11110111B     ;SET PA3 BACK LOW
04E5& B7 8000                              STAA   PORTAADR
04E8& 7E 006D&                             JMP    NEWSTART       ;RESTART FOR NEXT CALL
                       ;-----------------------------------------------------------------------
04EB& 42 49 52 44 42   ID               FCB  42H,49H,52H,44H,42H,4FH,52H,4EH,45H,20H ;BIRDBORNE
04F0& 4F 52 4E 45 20
04F5& 55 4E 49 54 20                    FCB  55H,4EH,49H,54H,20H,20H,31H             ;UNIT__1
04FA& 20 31
                       ; DIGITAL FILTER WEIGHTS STORED HERE
                       ; FOR THE FOLLOWING CENTER FREQUENCIES:
                       ; 250Hz,500Hz,750Hz,1000Hz,1250Hz,1500Hz,1750Hz,2000Hz,2250Hz,2500Hz
04FC& AB AE B9 CB E3   FILT01WGHT       FCB  -85,-82,-71,-53,-29,0,30,60,87,108,122
0501& 00 1E 3C 57 6C
0506& 7A
0507& 7F 7A 6C 57 3C                    FCB  127,122,108,87,60,30,0,-29,-53,-71,-82,-85
050C& 1E 00 E3 CB B9
0511& AE AB
0513& 4B 2E FF CB A0   FILT02WGHT       FCB  75,46,-1,-53,-96,-115,-103,-61,0,62,109,127
0518& 8D 99 C3 00 3E
051D& 6D 7F
051F& 6D 3E 00 C3 99                    FCB  109,62,0,-61,-103,-115,-96,-53,-1,46,75
0524& 8D A0 CB FF 2E
0529& 4B
052A& C2 00 46 69 4D   FILT03WGHT       FCB  -62,0,70,105,77,-1,-84,-122,-88,0,89,127
052F& FF AC 86 A8 00
0534& 59 7F
0536& 59 00 A8 86 AC                    FCB  89,0,-88,-122,-84,-1,77,105,70,0,-62
053B& FF 4D 69 46 00
0540& C2
0541& 2B D1 9C CB 36   FILT04WGHT       FCB  43,-47,-100,-53,54,114,59,-61,-124,-63,63,127
0546& 72 3B C3 84 C1
054B& 3F 7F
054D& 3F C1 84 C3 3B                    FCB  63,-63,-124,-61,59,114,54,-53,-100,-47,43
```

```
0552& 72 36 CB 9C D1
```



```
0557& 2B
0558& E9 51 46 CB 95      804 FILT05WGHT       FCB  -23,81,70,-53,-107,0,114,60,-88,-109,32,127
055D& 00 72 3C A8 93
0562& 20 7F
0564& 20 93 A8 3C 72      805                  FCB  32,-109,-88,60,114,0,-107,-53,70,81,-23
0569& 00 95 CB 46 51
056E& E9
056F& FF A2 00 69 FF      806 FILT06WGHT       FCB  -1,-94,0,105,-1,-115,0,121,-1,-126,0,127
0574& 8D 00 79 FF 82
0579& 00 7F
057B& 00 82 FF 79 00      807                  FCB  0,-126,-1,121,0,-115,-1,105,-94,-1
0580& 8D FF 69 A2 FF
0585& 16 51 B9 CB 6A      808 FILT07WGHT       FCB  22,81,-71,-53,106,-1,-115,60,87,-109,-33,127
058A& FF 8D 3C 57 93
058F& DF 7F
0591& DF 93 57 3C 8D      809                  FCB  -33,-109,87,60,-115,-1,106,-53,-71,81,22
0596& FF 6A CB B9 51
059B& 16
059C& D4 D1 63 CB C9      810 FILT08WGHT       FCB  -44,-47,99,-53,-55,114,-60,-61,123,-63,-64,127
05A1& 72 C4 C3 7B C1
05A6& C0 7F
05A8& C0 C1 7B C3 C4      811                  FCB  -64,-63,123,-61,-60,114,-55,-53,99,-47,-44
05AD& 72 C9 CB 63 D1
05B2& D4
05B3& 3D FF B9 69 B2      812 FILT09WGHT       FCB  61,-1,-71,105,-78,0,83,-122,87,-1,-90,127
05B8& 00 53 86 57 FF
05BD& A6 7F
05BF& A6 FF 57 86 53      813                  FCB  -90,-1,87,-122,83,0,-78,105,-71,-1,61
05C4& 00 B2 69 B9 FF
05C9& 3D
05CA& B4 2E FF CB 5F      814 FILT10WGHT       FCB  -76,46,-1,-53,95,-115,102,-61,0,62,-110,127
05CF& 8D 66 C3 00 3E
05D4& 92 7F
05D6& 92 3E 00 C3 66      815                  FCB  -110,62,0,-61,102,-115,95,-53,-1,46,-76
05DB& 8D 5F CB FF 2E
05E0& B4
                          816 ;
                          817 ; PARAMETERS FOR CORRELATION MATCHING ALGORITHM STORED HERE
```

```
                        818 ;FOR ANIMAL CALL TYPE1
```


```
                        819 ;WOLF HOWL COMPOSITE TEMPLATE
05E1& 7E 74 55 1E 15    820 MATCHEPOCH1T1   FCB  126,116,85,30,21,18,17,7,12,9
05E6& 12 11 07 0C 09
05EB& 84 79 53 28 14    821 MATCHEPOCH2T1   FCB  132,121,83,40,20,18,9,8,12,10
05F0& 12 09 08 0C 0A
05F5& 71 80 5C 22 16    822 MATCHEPOCH3T1   FCB  113,128,92,34,22,18,11,11,13,9
05FA& 12 0B 0B 0D 09
05FF& 77 77 4B 21 14    823 MATCHEPOCH4T1   FCB  119,119,75,33,20,17,10,8,13,9
0604& 11 0A 08 0D 09
0609& 7B 6D 48 1E 12    824 MATCHEPOCH5T1   FCB  123,109,72,30,18,17,10,6,12,9
060E& 11 0A 06 0C 09
0613& 82 6D 42 1A 14    825 MATCHEPOCH6T1   FCB  130,109,66,26,20,18,14,7,13,9
0618& 12 0E 07 0D 09
061D& 64 60 45 1A 13    826 MATCHEPOCH7T1   FCB  100,96,69,26,19,18,8,6,12,9
0622& 12 08 06 0C 09
0627& 55 56 3F 19 12    827 MATCHEPOCH8T1   FCB  85,86,63,25,18,16,6,6,12,7
062C& 10 06 06 0C 07
0631& 4A 3F 2B 18 11    828 MATCHEPOCH9T1   FCB  74,63,43,24,17,15,6,5,12,5
0636& 0F 06 05 0C 05
063B& 53 3E 31 1B 11    829 MATCHEPOCH10T1  FCB  83,62,49,27,17,15,5,4,12,6
0640& 0F 05 04 0C 06
                        830 ;FOR ANIMAL CALL TYPE2
                        831 ;WOLF GROWL COMPOSITE TEMPLATE
0645& 6C 5C 36 1C 1B    832 MATCHEPOCH1T2   FCB  108,92,54,28,27,25,29,23,18,9
064A& 19 1D 17 12 09
064F& 74 5E 44 22 1E    833 MATCHEPOCH2T2   FCB  116,94,68,34,30,29,36,25,20,12
0654& 1D 24 19 14 0C
0659& 7F 5F 39 1F 1D    834 MATCHEPOCH3T2   FCB  127,95,57,31,29,23,20,14,17,10
065E& 17 14 0E 11 0A
0663& 68 53 31 1C 1B    835 MATCHEPOCH4T2   FCB  104,83,49,28,27,24,27,17,17,10
0668& 18 1B 11 11 0A
066D& 62 54 39 1D 19    836 MATCHEPOCH5T2   FCB  98,84,57,29,25,24,23,20,19,10
0672& 18 17 14 13 0A
0677& 66 48 2F 1C 1A    837 MATCHEPOCH6T2   FCB  102,72,47,28,26,21,15,12,16,8
067C& 15 0F 0C 10 08
0681& 5A 33 26 1A 16    838 MATCHEPOCH7T2   FCB  90,51,38,26,22,19,15,10,16,8
0686& 13 0F 0A 10 08
068B& 53 5B 37 20 1A    839 MATCHEPOCH8T2   FCB  83,91,55,32,26,21,19,13,18,13
```

```
0690& 15 13 0D 12 0D
```



```
0695& 7E 50 2F 1D 1C      840 MATCHEPOCH9T2   FCB  126,80,47,29,28,20,19,14,16,9
069A& 14 13 0E 10 09
069F& 65 4A 34 1D 19      841 MATCHEPOCH10T2  FCB  101,74,52,29,25,23,21,18,17,9
06A4& 17 15 12 11 09
                          842 ;FOR ANIMAL CALL TYPE3
                          843 ;WOLF BARK COMPOSITE TEMPLATE
06A9& 3E 3B 3D 30 3E      844 MATCHEPOCH1T3   FCB  62,59,61,48,62,40,49,37,20,13
06AE& 28 31 25 14 0D
06B3& 3F 3F 30 28 2E      845 MATCHEPOCH2T3   FCB  63,63,48,40,46,29,42,30,17,10
06B8& 1D 2A 1E 11 0A
06BD& 3A 3B 33 2F 33      846 MATCHEPOCH3T3   FCB  58,59,51,47,51,30,40,26,16,11
06C2& 1E 28 1A 10 0B
06C7& 41 4E 33 36 30      847 MATCHEPOCH4T3   FCB  65,78,51,54,48,30,43,28,18,12
06CC& 1E 2B 1C 12 0C
06D1& 35 42 2C 38 2B      848 MATCHEPOCH5T3   FCB  53,66,44,56,43,24,27,19,13,8
06D6& 18 1B 13 0D 08
06DB& 30 36 32 31 32      849 MATCHEPOCH6T3   FCB  48,54,50,49,50,27,31,23,15,10
06E0& 1B 1F 17 0F 0A
06E5& 30 39 24 24 23      850 MATCHEPOCH7T3   FCB  48,57,36,36,35,23,27,20,14,8
06EA& 17 1B 14 0E 08
06EF& 32 3E 34 2E 30      851 MATCHEPOCH8T3   FCB  50,62,52,46,48,31,37,32,18,11
06F4& 1F 25 20 12 0B
06F9& 33 49 2C 26 25      852 MATCHEPOCH9T3   FCB  51,73,44,38,37,24,28,22,14,8
06FE& 18 1C 16 0E 08
0703& 43 5E 33 2C 2A      853 MATCHEPOCH10T3  FCB  67,94,51,44,42,28,33,26,13,10
0708& 1C 21 1A 0D 0A
                          854 ;FOR ANIMAL CALL TYPE 4
                          855 ;WOLF WHINE COMPOSITE TEMPLATE
070D& 46 66 24 29 1A      856 MATCHEPOCH1T4   FCB  70,102,36,41,26,39,38,14,16,10
0712& 27 26 0E 10 0A
0717& 4A 6B 22 2B 1E      857 MATCHEPOCH2T4   FCB  74,107,34,43,30,41,63,129,22,13
071C& 29 3F 81 16 0D
0721& 40 1E 14 15 10      858 MATCHEPOCH3T4   FCB  64,30,20,21,16,15,8,7,13,6
0726& 0F 08 07 0D 06
072B& 41 37 1B 18 13      859 MATCHEPOCH4T4   FCB  65,55,27,24,19,21,17,9,15,7
0730& 15 11 09 0F 07
0735& 5B 5E 2D 20 1C      860 MATCHEPOCH5T4   FCB  91,94,45,32,28,40,48,23,17,11
073A& 28 30 17 11 0B
```

```
073F& AB A6 4E 2F 37      861 MATCHEPOCH6T4    FCB  171,166,78,47,55,54,54,56,27,22
0744& 36 36 38 1B 16
```



```
0749& 46 2A 1A 22 1D      862 MATCHEPOCH7T4    FCB  70,42,26,34,29,25,26,17,19,11
074E& 19 1A 11 13 0B
0753& 41 21 18 16 11      863 MATCHEPOCH8T4    FCB  65,33,24,22,17,15,10,8,13,8
0758& 0F 0A 08 0D 08
075D& 34 1B 16 17 12      864 MATCHEPOCH9T4    FCB  52,27,22,23,18,36,16,17,30,21
0762& 24 10 11 1E 15
0767& 4C 26 15 16 14      865 MATCHEPOCH10T4   FCB  76,38,21,22,20,19,15,15,19,23
076C& 13 0F 0F 13 17
0771& 0B B8               866 THRESHOLD        FCB  0BH,0B8H                        ;THRESHOLD=3000
                          867 ;TOP OF EEPROM IS 07BFH=1983 BYTES
                          868 ;---------------------------------------------------------------------------------
                          869                     END
```

**Enclosure 3**
**BASIC Software for PC**

```
REM                          BIRDBORN PC TEST PROGRAM
REM                               WOLFTEST.BAS
REM                          TESTS DAHLGREN INTERFACE
REM
REM                       WRITTEN BY: PROTAGORAS CUTCHIS
REM
REM                 VERSION 1.2 - WEDNESDAY-AUGUST 26, 1998
REM                               TIME 3:40 PM
REM
REDU: DIM DIGITS%(20)
    ERRORS = 0
      OPEN "COM1:9600,N,8,1" FOR RANDOM AS #1 LEN = 256
    REM CONFIGURE RS232 PORT
    GOSUB INITDATE
    REM DEFINE FUNCTION KEYS ...
    KEY ON
    KEY 10, "QUIT"
     KEY(10) ON
     ON KEY(10) GOSUB SEEYA
HELLO: REM PRINT HELLO SCREEN ...
     CLS
     PRINT "PRESS 'F10' KEY AT ANY TIME TO QUIT THE PROGRAM "
     PRINT "      IF THE PROGRAM IS WAITING FOR YOU TO ENTER A NUMBER";
     PRINT " AND YOU WANT TO QUIT"
     PRINT "      PRESS ENTER AFTER PRESSING THE 'F10' KEY"
     LOCATE 7, 1
     GOTO TAGSTUF
STALL: REM CAUSES PROGRAMS TO WAIT 'TIMEDELAY' SECONDS TO ALLOW RECEIVER
       REM OR THE RS232 INTERFACE TO COMPLETE AN ACTION
       FOR XX = 1 TO 100
       FOR YY = 1 TO 20
       NEXT YY
       NEXT XX
            ' ADDS SMALL DELAY BEFORE CONTINUING TO ENSURE CURRENTTIMER
            ' IS GREATER THAN NOW
       RETURN

WEIGHT14: CURRENTTIMER = TIMER
          IF CURRENTTIMER > 86399.5 THEN GOTO WEIGHT14
          IF CURRENTTIMER < NOW THEN
               REM THIS IS TRUE ONLY WHEN TIMER RESETS TO 0 AT MIDNIGHT
               NOW = 0
          END IF
       IF CURRENTTIMER - NOW < TIMEDELAY THEN GOTO WEIGHT14
RETURN
```

```
REM @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
INITDATE: REM CONVERTS DATE AND TIME TO FILE NAME
        '
        ' FILE NAME  =   DDD_HHMM.DAT      WHERE
        ' DDD = DAY OF THE YEAR (1-365). AND HHMM = HOURS-MINUTES
          DAZE$ = DATE$
          DAY = VAL(MID$(DAZE$, 4, 2))
        MONTH = VAL(MID$(DAZE$, 1, 2))
        YEARS = VAL(MID$(DAZE$, 7, 4))
        IF MONTH = 1 THEN DAYNUM = 0
        IF MONTH = 2 THEN DAYNUM = 31
        IF MONTH = 3 THEN DAYNUM = 59
        IF MONTH = 4 THEN DAYNUM = 90
        IF MONTH = 5 THEN DAYNUM = 120
        IF MONTH = 6 THEN DAYNUM = 151
        IF MONTH = 7 THEN DAYNUM = 181
        IF MONTH = 8 THEN DAYNUM = 212
        IF MONTH = 9 THEN DAYNUM = 243
        IF MONTH = 10 THEN DAYNUM = 273
        IF MONTH = 11 THEN DAYNUM = 304
        IF MONTH = 12 THEN DAYNUM = 334
        IF YEARS MOD 4 = 0 AND DAYNUM >= 59 THEN DAYNUM = DAYNUM + 1
        DAYNUM = DAYNUM + DAY
        DAYNUMS$ = MID$(STR$(DAYNUM), 2, 3)
        HOUR$ = MID$(TIME$, 1, 2)
        MINS$ = MID$(TIME$, 4, 2)
        FILENAME$ = DAYNUMS$ + "_" + HOUR$ + MINS$
RETURN
REM @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
TAGSTUF:    PRINT "IT IS RECOMMENDED THAT THE SYSTEM ID BE CHECKED"
            PRINT "TO CONFIRM SYSTEM COMMUNICATIONS"
            PRINT "DO YOU WISH TO CONFIRM SYSTEM ID?"
            PRINT "ENTER Y/N"
TRYAGAIN1:  TAGVAR$ = INKEY$
            IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN GOTO GETID
            IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN CLS : GOTO NEXTTEST1
            GOTO TRYAGAIN1
GETID:      GOSUB GETID2
            GOTO NEXTTEST1
GETID2:     INNY$ = INPUT$(LOC(1), #1)
            EFLINE$ = "G"
            PRINT #1, EFLINE$
            GOSUB STALL
            RS232 = 99
            INNY$ = INPUT$(LOC(1), #1)
            RS232 = 11
```

```
            PRINT INNY$
            RETURN
NEXTTEST1:  NORMFLAG = 0
            PRINT "TEST OPTIONS ARE:"
            PRINT "  1) DUMP ALL FILTER WEIGHTS"
            PRINT "  2) DO A SINGLE TIME EPOCH FREQUENCY TEST"
            PRINT "  3) DO A MULTI-EPOCH FREQUENCY TEST"
            PRINT "  4) RECONFIRM UNIT ID CODE"
            PRINT "  5) TEST SIGNED MULTIPLY ROUTINE"
            PRINT "  6) TEST DIGITAL MEGA ADDITION ROUTINE"
            PRINT "  7) TEST A MULTI-TIME EPOCH MULTI-FREQUENCY FILTER RESPONSE"
            PRINT "  8) TEST THE NORMALIZATION ROUTINE"
            PRINT "  9) TEST DIGITAL FILTERS AND NORMALIZATION WITH ACTUAL RECORDED DATA"
            PRINT "  A) ANALYZE A RECORDING AND DUMP NORMALIZED PARAMETERS"
            PRINT "  B) DO A MATCH AGAINST A RECORDED REFERENCE"
            PRINT "  C) MATCH 2 STORED DATA FILES"
            PRINT "  D) TEST INTERFACE WITH DAHLGREN GPS/ARGOS UNITS"
            PRINT "  E) TEST DAHLGREN INTERFACE AND TRANSFER 8 BYTES"
            PRINT "ENTER 1-9 OR A-E"
TRYAGAIN2:  TAGVAR$ = INKEY$
            IF TAGVAR$ = "1" THEN CLS : GOTO DUMPWGHT
            IF TAGVAR$ = "2" THEN CLS : GOTO FILTTEST
            IF TAGVAR$ = "3" THEN CLS : GOTO WATERFALL
            IF TAGVAR$ = "4" THEN CLS : GOSUB GETID2: GOTO NEXTTEST1
            IF TAGVAR$ = "5" THEN CLS : GOTO MULTIPLY
            IF TAGVAR$ = "6" THEN CLS : GOTO MEGATEST
            IF TAGVAR$ = "7" THEN CLS : GOTO MULTTEST
            IF TAGVAR$ = "8" THEN CLS : GOTO NORMAL
            IF TAGVAR$ = "9" THEN CLS : GOTO AUDIO
            IF TAGVAR$ = "A" OR TAGVAR$ = "a" THEN CLS : GOTO ANALYZE1
            IF TAGVAR$ = "B" OR TAGVAR$ = "b" THEN CLS : GOTO CAPTURE
            IF TAGVAR$ = "C" OR TAGVAR$ = "c" THEN GOTO MATCH1
            IF TAGVAR$ = "D" OR TAGVAR$ = "d" THEN CLS : DAHLFLAG = 0: GOTO DAHLGREN
            IF TAGVAR$ = "E" OR TAGVAR$ = "e" THEN CLS : DAHLFLAG = 1: GOTO DAHLGREN
            GOTO TRYAGAIN2
MATCH1:     PRINT "ENTER FIRST FILE NAME."
            INPUT FILE1$
            PRINT "ENTER SECOND FILE NAME."
            INPUT FILE2$
            OPEN FILE1$ FOR INPUT AS #3
            FOR L = 1 TO 100
            INPUT #3, A(L)
            NEXT L
            CLOSE #3
            OPEN FILE2$ FOR INPUT AS #3
            FOR L = 1 TO 100
```

```
            INPUT #3, B(L)
            NEXT L
            CLOSE #3
            DIFF1 = 0: DIFF2 = 0
            FOR L = 1 TO 100
            DIFF1 = DIFF1 + ABS(A(L) - B(L))
            NEXT L
            FOR L = 1 TO 9
            FOR K = 0 TO 9
            INDEX = L + (K * 10)
            DIFF2 = DIFF2 + ABS(A(INDEX) - B(INDEX))
            NEXT K
            NEXT L
            PRINT "MATCH DIFFERENCE BASED ON STRAIGHT"
            PRINT "100 PARAMETER TIME/FREQ DISTRIBUTION IS: "; DIFF1
            PRINT " "
            PRINT "MATCH DIFFERENCE BASED ON 20 PARAMETER FREQ/VARIANCE"
            PRINT 'DISTRIBUTION IS: ";DIFF2
TA911A:     TAGVAR$ = INKEY$
            IF TAGVAR$ = " " THEN GOTO NEXTTEST1
            GOTO TA911A
ANALYZE1:   NORMFLAG = 1
            PRINT "START CAPTURE"
            PRINT "START TIME IS: "; TIME$: TSTRT = 3600 * VAL(LEFT$(TIME$, 2)) + 60 * VAL(MID$(TIME$, 4, 2)) +
VAL(RIGHT$(TIME$, 2))
            GOTO GETFILT8
            PRINT "WILL NOW WAIT FOR 12 MINUTES AND QUERY"
CHCKTIME1:  IF 3600 * VAL(LEFT$(TIME$, 2)) + 60 * VAL(MID$(TIME$, 4, 2)) + VAL(RIGHT$(TIME$, 2)) >= TSTRT + 800 THEN GOTO
NORMAL
            GOTO CHCKTIME1
DAHLGREN:   PRINT "HIT Y KEY AND ENTER WHEN YELLOW LIGHT STAYS LIT"
            PRINT "THIS WILL BE APPROXIMATELY 15 MINUTES AFTER CAPTURE"
GETY1:      TAGVAR$ = INKEY$
            IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN GOTO DAHL2
            GOTO GETY1
DAHL2:      PRINT " "
            PRINT " "
            PRINT "HIT MOMENTARY PUSHBUTTON SWITCH ON PROTOTYPE"
            PRINT "AND HOLD DOWN WHILE HITTING X AND ENTER."
GETX1:      TAGVAR$ = INKEY$
            IF TAGVAR$ = "X" OR TAGVAR$ = "x" THEN GOTO DAHL3
            FOR L = 1 TO 200
            NEXT L
            GOTO GETX1
DAHL3:      PRINT "OK"
            INNY$ = INPUT$(LOC(1), #1)
```

```
          EFLINE$ = "S"
          PRINT #1, EFLINE$
          RS232 = 99
          FOR L = 1 TO 200
          NEXT L
          INNY$ = INPUT$(LOC(1), #1)
          RS232 = 11
          EFLINE$ = "R"
          PRINT #1, EFLINE$
          RS232 = 99
          FOR L = 1 TO 500
          NEXT L
          INNY2$ = " "
          INNY2$ = INPUT$(LOC(1), #1)
          PRINT "ON SEND REQUEST:   DATA=: ";
          CHAR$ = LEFT$(INNY$, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          CHAR$ = MID$(INNY$, 2, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          CHAR$ = MID$(INNY$, 3, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          IF DAHLFLAG = 0 THEN GOTO RIGHT1
          CHAR$ = MID$(INNY$, 4, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          CHAR$ = MID$(INNY$, 5, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          CHAR$ = MID$(INNY$, 6, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          CHAR$ = MID$(INNY$, 7, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
RIGHT1:   CHAR$ = RIGHT$(INNY$, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          PRINT "  BYTES="; LEN(INNY$)
RETRAN1:  PRINT "ON RESEND REQUEST: DATA=: ";
          CHAR$ = LEFT$(INNY2$, 1)
          GOSUB ASCIIHEX
          PRINT A$; " ";
          CHAR$ = MID$(INNY2$, 2, 1)
```

```
           GOSUB ASCIIHEX
           PRINT A$; " ";
           CHAR$ = MID$(INNY2$, 3, 1)
           GOSUB ASCIIHEX
           PRINT A$; " ";
           IF DAHLFLAG = 0 THEN GOTO RIGHT2
           CHAR$ = MID$(INNY2$, 4, 1)
           GOSUB ASCIIHEX
           PRINT A$; " ";
           CHAR$ = MID$(INNY2$, 5, 1)
           GOSUB ASCIIHEX
           PRINT A$; " ";
           CHAR$ = MID$(INNY2$, 6, 1)
           GOSUB ASCIIHEX
           PRINT A$; " ";
           CHAR$ = MID$(INNY2$, 7, 1)
           GOSUB ASCIIHEX
           PRINT A$; " ";
RIGHT2:    CHAR$ = RIGHT$(INNY2$, 1)
           GOSUB ASCIIHEX
           PRINT A$; " ";
           PRINT "  BYTES="; LEN(INNY2$); ""
           GOTO DAHLGREN
CAPTURE:   PRINT "FIRST RECORD A REFERENCE ANIMAL CALL, THEN"
           PRINT "RECORD A TEST CALL.  HAVE THESE TWO THINGS BEEN"
           PRINT "BEEN COMPLETED? (Y/N)"
IN95:      TAGVAR$ = INKEY$
           IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN PRINT "THEN DO THEM NOW": PRINT " ": GOTO CAPTURE
           IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN GOTO CAPT2
           GOTO IN95
CAPT2:     PRINT "START TIME IS: "; TIME$
           INNY$ = INPUT$(LOC(1), #1)
           PRINT "HOST PC NOW AWAITING ANALYSIS COMPLETION"
           PRINT "ESTIMATED TIME IS 17 MINUTES FROM RECORDING"
           PRINT "OF TEST CALL"
           TEMP1$ = ""
GETMORE95: INNY$ = INPUT$(LOC(1), #1)
           IF INNY$ <> "" AND LEN(INNY$) > 4 THEN PRINT "ANALYSIS COMPLETED, WILL NOW REQUEST RESULTS": GOTO GETEM1
           IF INNY$ <> "" THEN TEMP1$ = TEMP1$ + INNY$
           IF LEN(TEMP1$) >= 6 THEN INNY$ = TEMP1$: GOTO GETEM1
           GOSUB STALL
           GOTO GETMORE95
GETEM1:    PRINT CHR$(7): GOSUB STALL: PRINT CHR$(7): PRINT INNY$
           GOSUB EVAL2
           PRINT "MATCH PARAMETER IS: "; CALCADD
           PRINT " ": PRINT "HIT THE SPACE BAR TO CONTINUE"
```

```
INSPACE1:  TAGVAR$ = INKEY$
           IF TAGVAR$ = " " THEN GOTO NEXTTEST1
           GOTO INSPACE1
NORMAL:    PRINT "YOU MUST PERFORM A FULL MULTI-FREQUENCY"
           PRINT "MULTI-EPOCH TEST FIRST.  HAS THIS BEEN DONE YET? (Y/N)"
TA1:       TAGVAR$ = INKEY$
           IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN GOTO NORM2
           IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN GOTO NEXTTEST1
           GOTO TA1
NORM2:     PRINT "DO YOU WISH TO WRITE THE DATA TO DISK?  (Y/N)"
TA911:     TAGVAR$ = INKEY$
           IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN WRITFLAG = 1: GOTO NORM3
           IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN WRITFLAG = 0: GOTO NORM3
           GOTO TA911
NORM3:     IF WRITFLAG = 1 THEN GOSUB INITDATE: OPEN FILENAME$ + ".DAT" FOR OUTPUT AS #3
           SUM = 0
           MIN = 256: MAX = 0
           FOR L = 1 TO 101
           EFLINE$ = "N"
           INNY$ = INPUT$(LOC(1), #1)
           PRINT #1, EFLINE$;
WAIT103:   FOR J = 1 TO 200
           NEXT J
           INNY$ = INPUT$(LOC(1), #1)
           D = VAL(INNY$)
           IF D < 0 THEN D = D + 256
           IF L = 1 THEN PRINT "AVERAGE CALCULATED IN uP IS: "; D: GOTO CCB
           IF INT((L - 1) / 10) = (L - 1) / 10 THEN PRINT D
           IF WRITFLAG = 1 THEN WRITE #3, D
           IF INT((L - 1) / 10) <> (L - 1) / 10 THEN PRINT D;
           IF D < MIN THEN MIN = D
           IF D > MAX THEN MAX = D
           SUM = SUM + D
CCB:       NEXT L
           PRINT "SUM= "; SUM; " AVERAGE = "; SUM / 100
           PRINT "MAX= "; MAX; "   MIN= "; MIN; "  MAX:AVE= "; MAX / (SUM / 100)
           CLOSE #3
TA2:       TAGVAR$ = INKEY$
           IF TAGVAR$ = " " THEN GOTO NEXTTEST1
           GOTO TA2
MULTTEST:  CLS
           PRINT "TRANSFER FREQUENCY PATTERN TO DACIS PROCESSOR"
ENTAMP2:   PRINT "ENTER PEAK AMPLITUDE:": INPUT AMP
           IF AMP > 127 THEN PRINT "AMPLITUDE TOO LARGE, TRY AGAIN": GOTO ENTAMP2
           PRINT "ENTER START FREQUENCY": INPUT STARTFREQ
INPEND:    PRINT "ENTER END FREQ": INPUT ENDFREQ
```

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            FOR L = 1 TO 3072
            PRINT L
            A = INT(AMP * SIN(2 * 3.14159 * FREQ * (L / 6000)))
            IF A < 0 THEN A = A + 256
            PRINT #1, CHR$(A);
            FOR K = 1 TO 3
            NEXT K
            NEXT L
            PRINT "DOWNLOAD FINISHED, WILL NOW CHECK FOR RECEPTION"
            EFLINE$ = "C"
            PRINT #1, EFLINE$;
            GOSUB STALL
            RS232 = 99
            GOTO STRTHERE:
AUDIO:      PRINT "DO YOU WANT TO PRINT PARAMETERS? (Y/N)";
TRY822:     TAGVAR$ = INKEY$
            IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN PRNTFLAG = 1: PRINT "YES": LPRINT DATE$: GOTO WRITEFILE
            IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN PRNTFLAG = 0: PRINT "NO": GOTO WRITEFILE
            GOTO TRY822
WRITEFILE:  PRINT "DO YOU WANT TO WRITE DATA TO DISK? (Y/N)";
TRY888:     TAGVAR$ = INKEY$
            IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN DISKFLAG = 1: PRINT "YES": GOTO AUDICONT
            IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN DISKFLAG = 0: PRINT "NO": GOTO AUDICONT
            GOTO TRY888
AUDICONT:   ANALNUM = 1
            PRINT "DO YOU WANT TO DO REPETITIVE AUTOMATIC ANALYSES? (Y/N)";
TRY420:     TAGVAR$ = INKEY$
            IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN AUTOFLAG = 1: PRINT "YES": GOTO STARTAUD
            IF TAGVAR$ = "N" OR TAGVAR$ = "y" THEN AUTOFLAG = 0: PRINT "NO": GOTO STARTAUD
            GOTO TRY420
STARTAUD:   IF AUTOFLAG = 1 THEN GOTO GETFILT8
            PRINT "HAS AN AUDIO CAPTURE BEEN PERFORMED? (Y/N)"
IN829:      TAGVAR$ = INKEY$
            IF TAGVAR$ = "Y" OR TAGVAR$ = "y" THEN GOTO GETFILT8
            IF TAGVAR$ = "N" OR TAGVAR$ = "n" THEN PRINT "THEN DO ONE NOW": GOTO NEXTTEST1
            GOTO IN829
MULTRECV:   PRINT "DOWNLOAD FINISHED, WILL NOW CHECK FOR RECEPTION"
            EFLINE$ = "C"
            PRINT #1, EFLINE$;
            GOSUB STALL
            RS232 = 99
            INNY$ = INPUT$(LOC(1), #1)
            RS232 = 11
            IF INNY$ = "X" THEN PRINT "DOWNLOAD SUCCESSFUL": GOTO GETFILT8
            IF INNY$ <> "X" THEN PRINT "DOWNLOAD WAS NOT SUCCESSFUL"
GETFILT8:   DCNT = 1
```

```
          IF PRNTFLAG = 1 THEN LPRINT "FREQ       "; "250  500  750  1000 1250 1500 1750 2000 2250 2500"
          FOR JJ = 1 TO 10
          SUMFILT(JJ) = 0
          NEXT JJ
          GETTIMFLG = 1
          IF NORMFLAG = 1 THEN GOTO GETFILT9
GETFILT6: GOTO GETFILT9
          EFLINE$ = "D"
          RS232 = 99
          PRINT #1, EFLINE$
          RS232 = 11
          FOR J = 1 TO 2000
          FOR K = 1 TO 10
          NEXT K
          NEXT J
          SUM1 = 0
GETFILT9: INNY$ = ""
INNY$ = INPUT$(LOC(1), #1)
          IF LEN(INNY$) >= 12 AND RIGHT$(INNY$, 1) = " " THEN GOTO GOTSAMP
          IF LEN(INNY$) <> 0 THEN INFIRST$ = INFIRST$ + INNY$
          IF LEN(INFIRST$) >= 12 THEN INNY$ = INFIRST$: INFIRST$ = "": GOTO GOTSAMP
          FOR R = 1 TO 500
          NEXT R
          GOTO GETFILT9
GOTSAMP:  IF GETTIMFLG = 1 AND DISKFLAG = 1 THEN GOSUB INITDATE
          IF GETTIMFLG = 1 THEN CLS : PRINT "DATE= "; DATE$; "  START="; TIME$; "  ANALYSIS NUMBER= "; ANALNUM: ANALNUM
= ANALNUM + 1
          IF GETTIMFLG = 1 THEN PRINT "FREQ       "; "250  500  750  1000 1250 1500 1750 2000 2250 2500"
          IF GETTIMFLG = 1 AND DISKFLAG = 1 THEN OPEN FILENAME$ + ".DAT" FOR OUTPUT AS #3
          IF GETTIMFLG = 1 AND DISKFLAG = 1 THEN PRINT #3, "DATE="; DATE$; "   TIME="; TIME$
          IF DISKFLAG = 1 AND GETTIMFLG = 1 THEN PRINT #3, "FREQ       "; "250  500  750  1000 1250 1500 1750 2000 2250
2500": GETTIMFLG = 0
          GOSUB EVAL1
          INDEX1 = DCNT - 10 * INT(DCNT / 10)
          N = INT((DCNT - 1) / 10) + 1: M = DCNT - 10 * (N - 1)
          IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 THEN PRINT "EPOCH"; (DCNT + 9) / 10; " ";
          IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND PRNTFLAG = 1 THEN LPRINT "EPOCH"; (DCNT + 9) / 10; " ";
          IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND DISKFLAG = 1 THEN PRINT #3, "EPOCH"; (DCNT + 9) / 10; " ";
          IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND DCNT <> 91 THEN PRINT " ";
          A$ = STR$(INT(CALCADD / 100000)): ZZ = INT(CALCADD / 100000)
          SUMFILT(INDEX1) = SUMFILT(INDEX1) + ZZ
          MATRIX(N, M) = ZZ
          SUM1 = SUM1 + ZZ
          GOSUB MAKE4
          GOTO PRINT104
MAKE4:    IF LEN(A$) = 1 THEN A$ = A$ + "    "
```

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           IF LEN(A$) = 2 THEN A$ = A$ + "   "
           IF LEN(A$) = 3 THEN A$ = A$ + "  "
           IF LEN(A$) = 4 THEN A$ = A$ + " "
           RETURN
PRINT104:  PRINT A$;
           IF PRNTFLAG = 1 THEN LPRINT A$;
           IF DISKFLAG = 1 THEN PRINT #3, A$;
           DCNT = DCNT + 1
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 THEN PRINT " "
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND PRNTFLAG = 1 THEN LPRINT " "
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND DISKFLAG = 1 THEN PRINT #3, " "
REM           IF DCNT = 101 THEN GOSUB FINDATA
REM           IF DCNT = 101 THEN PRINT "SUM= "; SUM1; "   AVERAGE= "; SUM1 / 100: GOTO CHCKSPACE
           IF DCNT = 101 THEN GOTO CHCKSPACE
           GOTO GETFILT9
CHCKSPACE: PRINT "NORMALIZED PARAMETERS"
           IF PRNTFLAG = 1 THEN LPRINT "NORMALIZED PARAMETERS"
           IF DISKFLAG = 1 THEN PRINT #3, "NORMALIZED PARAMETERS"
           PRINT "FREQ       "; "250  500  750  1000 1250 1500 1750 2000 2250 2500"
           IF DISKFLAG = 1 THEN PRINT #3, "250  500  750  1000 1250 1500 1750 2000 2250 2500"
           IF PRNTFLAG = 1 THEN LPRINT "FREQ     "; "250  500  750  1000 1250 1500 1750 2000 2250 2500"
           DCNT = 1: SUM = 0
REDO1019:  INFIRST$ = ""
GET1017:   INNY$ = ""
GET1018:   INNY$ = INPUT$(LOC(1), #1)
           IF LEN(INNY$) = 0 THEN GOTO GET1017
           IF RIGHT$(INNY$, 1) <> " " THEN INFIRST$ = INFIRST$ + INNY$: GOTO GET1018
           INFIRST$ = INFIRST$ + INNY$: A$ = INFIRST$: INFIRST$ = ""
           IF LEFT$(A$, 1) = " " THEN GOTO REDO1019
           IF LEFT$(A$, 1) = "-" THEN A$ = STR$(256 + VAL(A$))
           IF LEFT$(A$, 1) = " " THEN A$ = RIGHT$(A$, LEN(A$) - 1)
           IF LEFT$(A$, 1) = " " THEN A$ = RIGHT$(A$, LEN(A$) - 1)
           SUM = SUM + VAL(A$)
           GOSUB MAKE4
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 THEN PRINT "EPOCH"; (DCNT + 9) / 10; " ";
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND PRNTFLAG = 1 THEN LPRINT "EPOCH"; (DCNT + 9) / 10; " ";
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND DISKFLAG = 1 THEN PRINT #3, "EPOCH"; (DCNT + 9) / 10; " ";
           IF INT((DCNT - 1) / 10) = (DCNT - 1) / 10 AND DCNT <> 91 THEN PRINT "  ";
           IF INT(DCNT / 10) = DCNT / 10 THEN PRINT A$
           IF INT(DCNT / 10) = DCNT / 10 AND PRNTFLAG = 1 THEN LPRINT A$
           IF INT(DCNT / 10) = DCNT / 10 AND DISKFLAG = 1 THEN PRINT #3, A$
           IF INT(DCNT / 10) <> DCNT / 10 THEN PRINT A$;
           IF INT(DCNT / 10) <> DCNT / 10 AND PRNTFLAG = 1 THEN LPRINT A$;
           IF INT(DCNT / 10) <> DCNT / 10 AND DISKFLAG = 1 THEN PRINT #3, A$;
           DCNT = DCNT + 1
           IF DCNT = 101 THEN GOTO IN1017
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          GOTO GET1017
IN1017:   PRINT "AVERAGE IS:"; SUM / 100;
          IF PRNTFLAG = 1 THEN LPRINT "AVERAGE IS:"; SUM / 100
          IF DISKFLAG = 1 THEN PRINT #3, "AVERAGE IS:"; SUM / 100
          CLOSE #3
          IF AUTOFLAG = 1 THEN GOTO GETFILT8
IN10172:  TAGVAR$ = INKEY$
          IF TAGVAR$ = " " THEN GOTO NEXTTEST1
          GOTO IN10172
STRTHERE: INNY$ = INPUT$(LOC(1), #1)
          IF INNY$ = "X" THEN PRINT "DOWNLOAD SUCCESSFUL"
          IF INNY$ <> "X" THEN PRINT "DOWNLOAD NOT SUCCESSFUL": PRINT INNY$, LEN(INNY$)
NEXTFREQ: PRINT "AMPLITUDE= "; AMP; "     INPUT FREQUENCY= "; FREQ
          IF WRITDISK = 1 THEN PRINT #2, "AMPLITUDE= "; AMP; "     INPUT FREQUENCY="; FREQ
          RS232 = 11
          EFLINE$ = "D": SECONDS = 3600 * VAL(LEFT$(TIME$, 2)) + 60 * VAL(MID$(TIME$, 4, 2)) + VAL(RIGHT$(TIME$, 2))
          PRINT #1, EFLINE$;
          FOR J = 1 TO 3000
          FOR K = 1 TO 10
          NEXT K
          NEXT J
          RS232 = 99
GETFILT:  FREQREC = 0
GETFILT2: INNY$ = ""
GETFILT3: INNY$ = INPUT$(LOC(1), #1)
   '12=MINIMUM TRANSMISSION PER FILTER OUTPUT
          IF LEN(INNY$) >= 12 AND RIGHT$(INNY$, 1) = " " THEN GOTO PRINTDATA
          IF LEN(INNY$) <> 0 THEN INFIRST$ = INFIRST$ + INNY$
          IF LEN(INFIRST$) >= 12 THEN INNY$ = INFIRST$: INFIRST$ = "": GOTO PRINTDATA
          FOR L = 1 TO 500
          NEXT L
          GOTO GETFILT2
PRINTDATA: GOSUB EVAL1
          FILTTIME = 3600 * VAL(LEFT$(TIME$, 2)) + 60 * VAL(MID$(TIME$, 4, 2)) + VAL(RIGHT$(TIME$, 2)) - SECONDS
          PRINT "TIME TO COMPLETE FILTER= "; INT(FILTTIME / 60); ":"; FILTTIME - 60 * INT(FILTTIME / 60); "    ";
          IF WRITDISK = 1 THEN PRINT #2, "TIME TO COMPLETE FILTER= "; INT(FILTTIME / 60); ":"; FILTTIME - 60 *
INT(FILTTIME / 60); "    ";
          FREQREC = FREQREC + 1: ACTFREQ = 250 * FREQREC
          PRINT "FREQ="; ACTFREQ; "Hz  OUTPUT= "; CALCADD
          IF WRITDISK = 1 THEN PRINT #2, "FREQ= "; ACTFREQ; " Hz  OUTPUT= "; CALCADD
WAIT1:    IF DOALL = 1 AND FREQREC = 10 THEN GOTO CHECKALL
          IF FREQREC = 10 AND INKEY$ = " " THEN CLOSE #2: GOTO NEXTTEST1
          IF FREQREC <> 10 THEN GOTO GETFILT2
          GOTO WAIT1
CHECKALL: IF FREQ = 2500 THEN GOTO NEXTTEST1
          PRINT #2, "       "
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            FREQ = FREQ + 250: GOTO DUMPSINE
MEGATEST:   EFLINE$ = "B"
            CLS
MEGATEST2:  PRINT "THIS TEST WILL SUM ALL INTEGERS BETWEEN THE START"
            PRINT " AND ENDING VALUES AND RETURN THE RESULT"
            PRINT "ENTER START VALUE:": INPUT S1$: S1 = VAL(S1$)
            PRINT "ENTER END VALUE:": INPUT S2$: S2 = VAL(S2$)
            RESULT = ((S1 + S2) * (ABS(S2 - S1) + 1)) / 2
            IF S1 < S2 THEN LS1 = S1
            IF S1 < S2 THEN GS1 = S2
            IF S2 < S1 THEN LS1 = S2
            IF S2 < S1 THEN GS1 = S1
            IF LS1 >= 0 THEN LESSER1 = INT(LS1 / 256)
            IF LS1 >= 0 THEN LESSER2 = LS1 - 256 * LESSER1
            IF GS1 >= 0 THEN GREATER1 = INT(GS1 / 256)
            IF GS1 >= 0 THEN GREATER2 = GS1 - 256 * GREATER1
            IF LS1 < 0 THEN LESSER1 = 128 + INT((LS1 + 32768) / 256)
            IF LS1 < 0 THEN LESSER2 = (LS1 + 32768) - 256 * (LESSER1 - 128)
            IF GS1 < 0 THEN GREATER1 = 128 + INT((GS1 + 32768) / 256)
            IF GS1 < 0 THEN GREATER2 = (GS1 + 32768) - 256 * (GREATER1 - 128)
            INNY$ = INPUT$(LOC(1), #1)
            PRINT #1, EFLINE$
            FOR DELAY = 1 TO 400
            NEXT DELAY
            PRINT #1, CHR$(LESSER1)
            PRINT #1, CHR$(LESSER2)
            PRINT #1, CHR$(GREATER1)
            PRINT #1, CHR$(GREATER2)
            GOSUB STALL
            RS232 = 99
            INNY$ = INPUT$(LOC(1), #1)
            PRINT INNY$, LEN(INNY$)
            RS232 = 11
            GOSUB EVAL1
            GOTO DONE820
EVAL2:      FOR L = 1 TO 5
            IF MID$(INNY$, L, 1) = " " THEN LOHIBYTE = VAL(LEFT$(INNY$, L)): GOTO NEXT991
            NEXT L
NEXT991:    LOLOBYTE = VAL(RIGHT$(INNY$, LEN(INNY$) - L))
            A = 256 * LOHIBYTE + LOLOBYTE
            IF LOHIBYTE >= 0 AND LOLOBYTE < 0 THEN A = 256 * LOHIBYTE + (LOLOBYTE - 256)
            IF LOHIBYTE < 0 AND LOLOBYTE < 0 THEN A = 256 * (LOHIBYTE + 256) + (LOLOBYTE + 256)
            IF LOHIBYTE < 0 AND LOLOBYTE >= 0 THEN A = 256 * LOHIBYTE + (LOLOBYTE - 256)
            CALCADD = A
            RETURN
EVAL1:      FOR L = 1 TO 5
```

```
          IF MID$(INNY$, L, 1) = " " THEN LOHIBYTE = VAL(LEFT$(INNY$, L)): GOTO NEXT891
          NEXT L
NEXT891:  IF LEFT$(INNY$, 1) = "0" AND MID$(INNY$, 2, 1) = "0" THEN LOHIBYTE = 0
          FOR K = L + 1 TO L + 5
          IF MID$(INNY$, K, 1) = " " THEN LOLOBYTE = VAL(MID$(INNY$, L + 1, K - L)): GOTO NEXT892
          NEXT K
NEXT892:  IF MID$(INNY$, L + 1, 1) = "0" AND MID$(INNY$, L + 2, 1) = "0" THEN LOLOBYTE = 0
          FOR L = K + 1 TO K + 5
          IF MID$(INNY$, L, 1) = " " THEN HIHIBYTE = VAL(MID$(INNY$, K + 1, L - K)): GOTO NEXT81X
          NEXT L
NEXT81X:  IF MID$(INNY$, K + 1, 1) = "0" AND MID$(INNY$, K + 2, 1) = "0" THEN HIHIBYTE = 0
           HILOBYTE = VAL(RIGHT$(INNY$, LEN(INNY$) - L))
          GOTO NOPRINT
          PRINT INNY$; "  "; LOHIBYTE; "  "; LOLOBYTE; "  "; HIHIBYTE; "  "; HILOBYTE
NOPRINT:  A = 256 * LOHIBYTE + LOLOBYTE
          B = 256 * HIHIBYTE + HILOBYTE
          IF LOHIBYTE >= 0 AND LOLOBYTE < 0 THEN A = LOHIBYTE * 256 + (LOLOBYTE + 256)
          IF HIHIBYTE >= 0 AND HILOBYTE < 0 THEN B = HIHIBYTE * 256 + (HILOBYTE + 256)
          IF LOHIBYTE < 0 AND LOLOBYTE < 0 THEN A = ((LOHIBYTE + 256) * 256) + (LOLOBYTE + 256) - 65536
          IF HIHIBYTE < 0 AND HILOBYTE < 0 THEN B = ((HIHIBYTE + 256) * 256) + (HILOBYTE + 256) - 65536
          IF LOHIBYTE < 0 AND LOLOBYTE >= 0 THEN A = ((LOHIBYTE + 256) * 256) + LOLOBYTE - 65536
          IF HIHIBYTE < 0 AND HILOBYTE >= 0 THEN B = ((HIHIBYTE + 256) * 256) + HILOBYTE - 65536
          CALCADD = B * 32768 + A
          RETURN
DONE820:  PRINT "A="; A; "B="; B
          PRINT "CALCULATED SUM="; RESULT
          PRINT "PROCESSOR SUM="; CALCADD
          GOTO NEXTTEST1
MULTIPLY: PRINT "ENTER VALUE 1=-128 TO +127"
          INPUT A1
          IF A1 < -128 OR A1 > 127 THEN GOTO MULTIPLY
          X1 = A1
          IF A1 < 0 THEN A1 = A1 + 256
          PRINT A1, STR$(A1), LEN(STR$(A1)), RIGHT$(STR$(A1), 2), VAL(STR$(A1))
A2AGAIN:  PRINT "ENTER SECOND VALUE =-128 TO +127"
          INPUT A2
          IF A2 < -128 OR A2 > 127 THEN GOTO A2AGAIN
          X2 = A2
          IF A2 < 0 THEN A2 = A2 + 256
          INNY$ = INPUT$(LOC(1), #1)
          EFLINE$ = "M"
          PRINT #1, EFLINE$
          FOR DELAY = 1 TO 300
          NEXT DELAY
          PRINT #1, CHR$(A1)
          FOR DELAY = 1 TO 300
```

```
          NEXT DELAY
          PRINT #1, CHR$(A2)
          FOR DELAY = 1 TO 300
          NEXT DELAY
          RS232 = 99
          INNY$ = INPUT$(LOC(1), #1)
          RS232 = 11
          FOR L = 1 TO 4
          IF MID$(INNY$, L, 1) = " " THEN HIGHBYTE = VAL(LEFT$(INNY$, LEN(INNY$) - L))
          NEXT L
          IF LEFT$(INNY$, 1) = "0" AND MID$(INNY$, 2, 1) = "0" THEN HIGHBYTE = 0
          FOR L = 1 TO 8
          IF MID$(INNY$, L, 1) = " " THEN LOWBYTE = VAL(RIGHT$(INNY$, LEN(INNY$) - L)): GOTO PRINTMUL
          NEXT L
PRINTMUL: IF LOWBYTE < 0 THEN LOWBYTE = LOWBYTE + 256
          PRINT INNY$, HIGHBYTE, LOWBYTE
          PRINT "MULTIPLIED RESULT IS:"; HIGHBYTE * 256 + LOWBYTE
          PRINT "EXPECTED RESULT IS: "; X1 * X2
          GOTO NEXTTEST1
DUMPWGHT: INNY$ = INPUT$(LOC(1), #1)
          FOR L = 1 TO 10
          LINER$ = "FILTER"
          IF L < 10 THEN LINER$ = "FILTER "
          PRINT LINER$; L; " ";
          FOR K = 1 TO 23
          EFLINE$ = "F"
          PRINT #1, EFLINE$
          FOR DELAY = 1 TO 300
          NEXT DELAY
          RS232 = 99
          INNY$ = INPUT$(LOC(1), #1)
          RS232 = 11
          IF LEN(INNY$) = 3 THEN INNY$ = " " + INNY$
          IF LEN(INNY$) = 2 THEN INNY$ = "  " + INNY$
          IF LEN(INNY$) = 1 THEN INNY$ = "   " + INNY$
          PRINT INNY$;
          IF K <> 11 THEN PRINT ",";
          NEXT K
          PRINT " "
          NEXT L
          GOTO NEXTTEST1
SPECTRUM: INNY$ = INPUT$(LOC(1), #1)
          PRINT "FREQUENCY      POWER"
          FOR L = 1 TO 10
          FREQ = 250 * L
          PRINT "   "; FREQ; "      ";
```

```
           EFLINE$ = "O"
           PRINT #1, EFLINE$
           FOR DELAY = 1 TO 300
           NEXT DELAY
           RS232 = 99
           INNY$ = INPUT$(LOC(1), #1)
           RS232 = 11
           POWER = VAL(INNY$)
           IF POWER < 0 THEN POWER = POWER + 256
           PRINT POWER
           NEXT L
           GOTO NEXTTEST1
WATERFALL: PRINT "FREQ.  EPOCH1 EPOCH2 EPOCH3 EPOCH4 EPOCH5 EPOCH6 EPOCH7 EPOCH8 EPOCH9 EPOCH10"
           FOR L = 1 TO 10
           FREQ = 250 * L
           A$ = STR$(FREQ)
           IF LEN(A$) < 5 THEN A$ = A$ + " "
           PRINT A$; " ";
           EFLINE$ = "W"
           FOR J = 1 TO 10
           PRINT #1, EFLINE$
           FOR DELAY = 1 TO 300
           NEXT DELAY
           RS232 = 99
           INNY$ = INPUT$(LOC(1), #1)
           RS232 = 11
           POWER = VAL(INNY$)
           IF POWER < 0 THEN POWER = POWER + 256
           POW$ = STR$(POWER)
           IF LEN(POW$) = 3 THEN POW$ = POW$ + "  "
           IF LEN(POW$) = 4 THEN POW$ = POW$ + " "
           IF LEN(POW$) = 2 THEN POW$ = POW$ + "   "
           IF LEN(POW$) = 1 THEN POW$ = POW$ + "    "
           PRINT POW$; "  ";
           NEXT J
           PRINT " "
           NEXT L
           GOTO NEXTTEST1
FINDATA:   PRINT "AVERAGE   ";
           FOR M = 1 TO 10
           SUMROW = 0
           FOR N = 1 TO 10
           SUMROW = SUMROW + MATRIX(N, M)
           NEXT N
           A$ = STR$(INT(SUMROW / 10))
           GOSUB MAKE4
```

```
           PRINT A$;
           NEXT M
           PRINT " "
           PRINT "ABSDEV    "
           FOR M = 1 TO 10
           ABSDEV = 0
           FOR N = 1 TO 10
           SUMROW = SUMROW + MATRIX(N, M)
           NEXT N
           ROWAVE = SUMROW / 10
           FOR N = 1 TO 10
           ABSDEV = ABSDEV + ABS(MATRIX(N, M) - ROWAVE)
           NEXT N
           A$ = STR$(INT(ABSDEV / 10))
           GOSUB MAKE4
           PRINT A$;
           NEXT M
           PRINT " "
           RETURN
ASCII:     FOR L = 0 TO 255
           IF CHR$(L) = CHAR$ THEN VALUE = L: A$ = STR$(VALUE): RETURN
           NEXT L
           RETURN
ASCIIHEX:  FOR L = 0 TO 255
           IF CHR$(L) = CHAR$ THEN VALUE = L: GOTO CONVERTH
           NEXT L
           RETURN
CONVERTH:  A = INT(VALUE / 16)
           IF A > 9 THEN GOSUB CONVERTH1: GOTO SKIPIT1
           C$ = STR$(A)
SKIPIT1:   A$ = C$:
           B = VALUE - (16 * A)
           IF B > 9 THEN GOSUB CONVERTH1: GOTO SKIPIT2
           C$ = STR$(B)
SKIPIT2:   A$ = A$ + RIGHT$(C$, 1) + "H"
           RETURN
CONVERTH1: IF A = 10 THEN C$ = "A"
           IF A = 11 THEN C$ = "B"
           IF A = 12 THEN C$ = "C"
           IF A = 13 THEN C$ = "D"
           IF A = 14 THEN C$ = "E"
           IF A = 15 THEN C$ = "F"
           RETURN
SEEYA:     PRINT "PROGRAM ABORTED"
           END
           RETURN
```

**Enclosure 4**
**Filter Output Data and Analysis of Wolf Calls**

| HOWL COMPOSITE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **250** | **500** | **750** | **1000** | **1250** | **1500** | **1750** | **2000** | **2250** | **2500** |
| EPOCH 1 | 126 | 116 | 85 | 29.5 | 21 | 18 | 16.75 | 6.5 | 12 | 9.25 |
| EPOCH 2 | 132 | 120.5 | 82.5 | 39.5 | 19.75 | 17.75 | 8.5 | 7.75 | 12.25 | 10.25 |
| EPOCH 3 | 113 | 127.5 | 91.5 | 34 | 22 | 18.25 | 11.25 | 11 | 12.75 | 9.25 |
| EPOCH 4 | 118.75 | 118.75 | 74.75 | 32.5 | 19.5 | 17.25 | 9.5 | 8.25 | 12.75 | 9 |
| EPOCH 5 | 122.75 | 109.25 | 71.5 | 29.5 | 18.25 | 16.75 | 10 | 5.75 | 12 | 9.25 |
| EPOCH 6 | 129.75 | 109.25 | 65.5 | 25.75 | 20.25 | 17.75 | 14.25 | 6.5 | 12.75 | 9.25 |
| EPOCH 7 | 100.25 | 96 | 68.75 | 25.75 | 19 | 17.75 | 8 | 6.25 | 12.25 | 8.5 |
| EPOCH 8 | 85.25 | 85.5 | 63.25 | 25.25 | 18.5 | 16 | 6.25 | 6.25 | 12.25 | 7 |
| EPOCH 9 | 74.5 | 63.25 | 42.75 | 23.5 | 16.5 | 15 | 5.5 | 5.25 | 12 | 5 |
| EPOCH 10 | 82.75 | 61.75 | 48.5 | 27 | 16.5 | 15 | 4.5 | 4.25 | 12 | 6 |
| SUM | 1085 | 1007.75 | 694 | 292.25 | 191.25 | 169.5 | 94.5 | 67.75 | 123 | 82.75 |
| STDV | 21.26 | 23.54 | 15.41 | 4.91 | 1.78 | 1.22 | 3.85 | 1.87 | 0.33 | 1.69 |
| **GROWL COMPOSITE** | | | | | | | | | | |
| | **250** | **500** | **750** | **1000** | **1250** | **1500** | **1750** | **2000** | **2250** | **2500** |
| EPOCH 1 | 107.5 | 91.75 | 54 | 28 | 27 | 24.5 | 29.25 | 22.5 | 17.5 | 9.25 |
| EPOCH 2 | 116.25 | 94.25 | 67.5 | 33.5 | 30.25 | 28.75 | 35.5 | 24.75 | 19.75 | 11.5 |
| EPOCH 3 | 126.75 | 94.75 | 57 | 30.75 | 28.5 | 23 | 20.25 | 13.5 | 17.25 | 9.75 |
| EPOCH 4 | 103.5 | 82.5 | 49 | 28 | 27.25 | 23.5 | 26.5 | 16.75 | 16.5 | 9.5 |
| EPOCH 5 | 97.75 | 84.25 | 57.25 | 28.75 | 25 | 24 | 23.25 | 19.5 | 18.5 | 9.5 |
| EPOCH 6 | 102 | 71.5 | 47.25 | 28.25 | 26.25 | 20.75 | 14.75 | 12 | 15.75 | 8.25 |
| EPOCH 7 | 90.25 | 50.75 | 38.25 | 25.5 | 22 | 19.25 | 14.5 | 10 | 15.5 | 7.5 |
| EPOCH 8 | 83.25 | 90.75 | 55.25 | 32.25 | 25.75 | 21.25 | 18.75 | 13.25 | 18.25 | 12.75 |
| EPOCH 9 | 125.75 | 79.75 | 46.75 | 28.5 | 27.75 | 20.25 | 19 | 14 | 15.75 | 8.75 |
| EPOCH 10 | 101 | 73.75 | 51.5 | 28.75 | 25.25 | 22.75 | 21 | 17.5 | 17 | 8.75 |
| SUM | 1054 | 814 | 523.75 | 292.25 | 265 | 228 | 222.75 | 163.75 | 171.75 | 95.5 |
| STDV | 14.16 | 13.52 | 7.85 | 2.32 | 2.24 | 2.71 | 6.57 | 4.74 | 1.37 | 1.54 |
| **BARK COMPOSITE** | | | | | | | | | | |
| | **250** | **500** | **750** | **1000** | **1250** | **1500** | **1750** | **2000** | **2250** | **2500** |
| EPOCH 1 | 62 | 59.25 | 61.25 | 48 | 61.5 | 39.75 | 48.75 | 36.5 | 20 | 13.25 |
| EPOCH 2 | 63.25 | 62.5 | 47.5 | 40 | 45.75 | 28.75 | 42 | 30 | 17 | 9.75 |
| EPOCH 3 | 57.5 | 58.5 | 50.5 | 47 | 50.5 | 30 | 40 | 26 | 16 | 10.5 |
| EPOCH 4 | 64.5 | 77.5 | 51 | 54.25 | 47.5 | 29.75 | 42.75 | 27.75 | 17.5 | 11.5 |
| EPOCH 5 | 53 | 66.25 | 44.25 | 56 | 42.75 | 23.5 | 26.75 | 18.75 | 13.25 | 8 |
| EPOCH 6 | 48.25 | 53.75 | 49.75 | 48.5 | 50 | 27.25 | 30.75 | 22.5 | 15 | 9.75 |
| EPOCH 7 | 47.5 | 56.75 | 36.25 | 35.75 | 35 | 22.5 | 26.75 | 20.25 | 13.75 | 7.75 |
| EPOCH 8 | 49.75 | 61.75 | 51.5 | 45.5 | 48 | 30.5 | 36.5 | 31.75 | 17.75 | 11 |
| EPOCH 9 | 51.25 | 73.25 | 44.25 | 37.75 | 36.5 | 23.75 | 28.25 | 22 | 13.5 | 8 |
| EPOCH 10 | 67.25 | 94.25 | 51 | 43.75 | 42 | 27.75 | 32.5 | 26 | 13.25 | 9.75 |
| SUM | 564.25 | 663.75 | 487.25 | 456.5 | 459.5 | 283.5 | 355 | 261.5 | 157 | 99.25 |
| STDV | 7.38 | 12.24 | 6.47 | 6.60 | 7.61 | 4.94 | 25.00 | 5.54 | 2.33 | 1.74 |
| **WHINE COMPOSITE** | | | | | | | | | | |
| | **250** | **500** | **750** | **1000** | **1250** | **1500** | **1750** | **2000** | **2250** | **2500** |
| EPOCH 1 | 70 | 102.25 | 36.25 | 40.5 | 26 | 39.5 | 37.5 | 13.75 | 16 | 10.25 |
| EPOCH 2 | 74 | 106.5 | 33.75 | 42.5 | 29.5 | 41 | 63 | 129 | 22 | 13 |
| EPOCH 3 | 63.75 | 30 | 19.75 | 20.75 | 15.75 | 14.75 | 7.5 | 6.75 | 13 | 6.25 |
| EPOCH 4 | 65.25 | 55.25 | 27.25 | 24 | 18.75 | 20.75 | 17.25 | 8.75 | 14.75 | 7 |
| EPOCH 5 | 91.25 | 93.75 | 44.5 | 32 | 28 | 39.25 | 47.5 | 22.75 | 17 | 11 |
| EPOCH 6 | 171 | 166 | 77.5 | 46.75 | 54.75 | 53.75 | 54 | 55.5 | 26.5 | 22.25 |
| EPOCH 7 | 69.75 | 41.5 | 25.75 | 34.25 | 29 | 25 | 25.75 | 17 | 19.25 | 11 |
| EPOCH 8 | 64.5 | 33.25 | 24 | 22 | 17 | 15.25 | 9.75 | 8.25 | 13 | 8 |
| EPOCH 9 | 52 | 26.75 | 21.75 | 23.25 | 18.25 | 36.25 | 15.5 | 16.75 | 30 | 20.55 |
| EPOCH 10 | 75.25 | 37.5 | 21 | 22 | 20 | 18.75 | 14.75 | 15 | 19.25 | 22.75 |
| SUM | 796.75 | 692.75 | 331.5 | 308 | 257 | 304.25 | 292.5 | 293.5 | 190.75 | 317 |
| STDV | 33.63 | 46.01 | 17.44 | 9.76 | 11.48 | 13.27 | 25.00 | 37.71 | 5.67 | 61.34 |

| **COMPARISON MATRIX** | | | | |
|---|---|---|---|---|
| | HOWL COMP. | GROWL COMP. | BARK COMP. | WHINE COMP |
| HOWL1 | 13.74056494 | 21.24445516 | 33.45437191 | 38.40712824 |
| HOWL2 | 16.80887043 | 22.16059284 | 35.22939114 | 39.9940308 |
| HOWL3 | 14.69347219 | 23.91959187 | 35.05909297 | 40.15504327 |
| HOWL4 | 24.86761197 | 26.65148917 | 31.79158694 | 43.17218433 |
| GROWL1 | 29.80181412 | 19.85414 | 29.29334395 | 42.67718946 |
| GROWL2 | 18.01577434 | 14.64980802 | 27.15059852 | 30.23024148 |
| GROWL3 | 22.19488961 | 14.35502961 | 24.54251413 | 37.0136799 |
| GROWL4 | 17.44485956 | 16.59975527 | 24.74772717 | 36.97516058 |
| BARK1 | 31.91814727 | 25.19080934 | 11.99979166 | 33.94521321 |
| BARK2 | 32.46295004 | 26.74905372 | 19.02971361 | 41.93599289 |
| BARK3 | 32.54901112 | 25.52580802 | 13.86001443 | 39.13537402 |
| BARK4 | 33.95383815 | 26.61506857 | 17.09312727 | 34.49213679 |
| WHINE1 | 36.71986009 | 33.99568906 | 35.50880173 | 2.739981752 |
| WHINE2 | 36.41899401 | 33.21719246 | 34.08364711 | 1.103403825 |
| WHINE3 | 36.21716616 | 32.8367458 | 33.29391836 | 2.225421308 |
| WHINE4 | 35.71460661 | 32.577168 | 33.57655432 | 1.724093965 |
| | | | | |
| THRESHOLD | | | | |
| 17 | | | | |
| | % POS CORR. | FALSE NEG | %NEG CORR. | FALSE POS |
| | 75 | 25 | 100 | 0 |
| | **TOTAL CORRECT RATE** | | | |
| | **93.75** | | | |

AVERAGE IS: 38.21 08-29-1997

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 651 | 648 | 757 | 169 | 139 | 106 | 52 | 50 | 69 | 66 |
| EPOCH 2 | 621 | 879 | 904 | 175 | 120 | 112 | 49 | 47 | 69 | 79 |
| EPOCH 3 | 543 | 816 | 600 | 174 | 126 | 98 | 59 | 41 | 72 | 51 |
| EPOCH 4 | 596 | 617 | 356 | 232 | 109 | 91 | 59 | 39 | 69 | -9396 |
| EPOCH 5 | 702 | 639 | 240 | 233 | 107 | 87 | 41 | 34 | 69 | 50 |
| EPOCH 6 | 686 | 692 | 245 | 137 | 100 | 85 | 50 | 35 | 71 | 42 |
| EPOCH 7 | 605 | 595 | 241 | 129 | 100 | 85 | 51 | 28 | 69 | 45 |
| EPOCH 8 | 7877 | 397 | 148 | 117 | 94 | 81 | 28 | 23 | 68 | 37 |
| EPOCH 9 | 451 | 261 | 115 | 112 | 87 | 80 | 26 | 22 | 68 | 29 |
| EPOCH 10 | 338 | 195 | 107 | 120 | 86 | 80 | 25 | 22 | 68 | 26 |

NORMALIZED PARAMETERS

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1750 | 2000 | 2250 | 2500 | |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 121 | 121 | 140 | 30 | 25 | 19 | 09 | 08 | 12 | 12 |
| EPOCH 2 | 115 | 164 | 167 | 31 | 22 | 20 | 08 | 08 | 12 | 14 |
| EPOCH 3 | 100 | 152 | 111 | 31 | 23 | 18 | 11 | 07 | 13 | 08 |
| EPOCH 4 | 110 | 115 | 66 | 42 | 19 | 15 | 11 | 06 | 12 | 08 |
| EPOCH 5 | 131 | 118 | 44 | 42 | 19 | 15 | 07 | 06 | 12 | 08 |
| EPOCH 6 | 127 | 128 | 45 | 25 | 18 | 15 | 08 | 06 | 12 | 07 |
| EPOCH 7 | 112 | 110 | 44 | 23 | 18 | 15 | 08 | 04 | 12 | 07 |
| EPOCH 8 | 100 | 73 | 26 | 20 | 17 | 14 | 04 | 03 | 12 | 06 |
| EPOCH 9 | 83 | 47 | 20 | 20 | 15 | 14 | 04 | 03 | 12 | 04 |
| EPOCH 10 | 66 | 35 | 19 | 22 | 15 | 14 | 03 | 03 | 12 | 04 |

08-29-1997

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 955 | 636 | 232 | 149 | 100 | 97 | 44 | 31 | 70 | 57 |
| EPOCH 2 | 923 | 686 | 301 | 169 | 109 | 103 | 49 | 39 | 72 | 59 |
| EPOCH 3 | 877 | 868 | 642 | 201 | 136 | 119 | 107 | 74 | 73 | 68 |
| EPOCH 4 | 947 | 852 | 589 | 209 | 128 | 130 | 91 | 72 | 70 | 75 |
| EPOCH 5 | 1107 | 932 | 523 | 185 | 111 | 125 | 125 | 51 | 71 | 79 |
| EPOCH 6 | 1045 | 767 | 379 | 174 | 125 | 142 | 250 | 63 | 86 | 87 |
| EPOCH 7 | 629 | 468 | 282 | 162 | 122 | 122 | 97 | 71 | 74 | 53 |
| EPOCH 8 | 421 | 493 | 526 | 164 | 117 | 97 | 53 | 81 | 68 | 56 |
| EPOCH 9 | 342 | 390 | 420 | 145 | 95 | 89 | 46 | 64 | 68 | 45 |
| EPOCH 10 | 332 | 348 | 651 | 127 | 98 | 84 | 38 | 35 | 68 | 52 |

NORMALIZED PARAMETERS

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1750 | 2000 | 2250 | 2500 | |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 145 | 97 | 35 | 22 | 15 | 14 | 06 | 04 | 10 | 08 |
| EPOCH 2 | 140 | 104 | 46 | 25 | 16 | 15 | 07 | 06 | 11 | 09 |
| EPOCH 3 | 133 | 132 | 98 | 30 | 20 | 18 | 16 | 11 | 11 | 10 |
| EPOCH 4 | 144 | 130 | 89 | 31 | 19 | 19 | 13 | 11 | 10 | 11 |
| EPOCH 5 | 169 | 142 | 79 | 28 | 16 | 19 | 19 | 07 | 10 | 12 |
| EPOCH 6 | 159 | 117 | 57 | 26 | 19 | 21 | 38 | 09 | 13 | 13 |
| EPOCH 7 | 96 | 71 | 43 | 24 | 18 | 18 | 14 | 10 | 11 | 08 |
| EPOCH 8 | 64 | 75 | 80 | 25 | 17 | 14 | 08 | 12 | 10 | 08 |
| EPOCH 9 | 52 | 59 | 64 | 22 | 14 | 13 | 07 | 09 | 10 | 06 |
| EPOCH 10 | 50 | 53 | 99 | 19 | 14 | 13 | 05 | 05 | 10 | 07 |

9/3
~~08-29~~-1997

GROWL at 650

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 519 | 400 | 170 | 131 | 116 | 129 | 184 | 87 | 80 | 51 |
| EPOCH 2 | 660 | 604 | 369 | 193 | 175 | 204 | 371 | 223 | 126 | 90 |
| EPOCH 3 | 736 | 561 | 329 | 157 | 159 | 142 | 136 | 104 | 92 | 58 |
| EPOCH 4 | 542 | 370 | 160 | 118 | 104 | 94 | 62 | 58 | 84 | 40 |
| EPOCH 5 | 632 | 530 | 368 | 166 | 143 | 149 | 164 | 140 | 118 | 61 |
| EPOCH 6 | 834 | 677 | 370 | 188 | 185 | 124 | 105 | 69 | 93 | 71 |
| EPOCH 7 | 322 | 167 | 105 | 110 | 87 | 80 | 32 | 24 | 68 | 27 |
| EPOCH 8 | 360 | 306 | 198 | 121 | 97 | 84 | 38 | 33 | 69 | 31 |
| EPOCH 9 | 421 | 386 | 256 | 130 | 132 | 98 | 96 | 87 | 77 | 35 |
| EPOCH 10 | 457 | 378 | 278 | 127 | 124 | 90 | 63 | 56 | 70 | 34 |

NORMALIZED PARAMETERS

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 103 | 79 | 34 | 24 | 22 | 24 | 36 | 17 | 15 | 09 |
| EPOCH 2 | 131 | 120 | 73 | 38 | 34 | 40 | 73 | 44 | 24 | 17 |
| EPOCH 3 | 146 | 111 | 65 | 31 | 31 | 27 | 26 | 19 | 18 | 10 |
| EPOCH 4 | 107 | 73 | 31 | 23 | 19 | 18 | 11 | 10 | 15 | 07 |
| EPOCH 5 | 125 | 105 | 73 | 32 | 27 | 28 | 32 | 27 | 23 | 11 |
| EPOCH 6 | 165 | 134 | 73 | 36 | 36 | 23 | 20 | 13 | 18 | 13 |
| EPOCH 7 | 64 | 32 | 20 | 20 | 17 | 15 | 05 | 03 | 13 | 05 |
| EPOCH 8 | 72 | 60 | 39 | 23 | 18 | 15 | 06 | 06 | 13 | 05 |
| EPOCH 9 | 83 | 77 | 51 | 24 | 26 | 18 | 18 | 17 | 14 | 06 |
| EPOCH 10 | 90 | 74 | 55 | 24 | 23 | 17 | 11 | 10 | 13 | 06 |

AVERAGE IS: 38.79

9/2
~~08-29~~-1997

GROWN at 660 ON TAPE

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 496 | 512 | 365 | 151 | 149 | 140 | 183 | 167 | 104 | 63 |
| EPOCH 2 | 351 | 195 | 184 | 127 | 106 | 94 | 53 | 42 | 71 | 35 |
| EPOCH 3 | 447 | 239 | 196 | 130 | 101 | 98 | 93 | 65 | 87 | 56 |
| EPOCH 4 | 493 | 293 | 199 | 137 | 128 | 125 | 124 | 89 | 91 | 60 |
| EPOCH 5 | 327 | 159 | 104 | 109 | 90 | 80 | 38 | 27 | 68 | 25 |
| EPOCH 6 | 328 | 159 | 103 | 110 | 86 | 80 | 38 | 33 | 69 | 28 |
| EPOCH 7 | 441 | 185 | 134 | 122 | 105 | 101 | 5 | 58 | 77 | 37 |
| EPOCH 8 | 1880 | 634 | 334 | 211 | 152 | 117 | 93 | 78 | 112 | 120 |
| EPOCH 9 | 1014 | 375 | 195 | 156 | 118 | 101 | 69 | 52 | 84 | 71 |
| EPOCH 10 | 577 | 278 | 182 | 154 | 126 | 106 | 73 | 59 | 83 | 48 |

NORMALIZED PARAMETERS

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 118 | 123 | 87 | 36 | 34 | 33 | 44 | 39 | 23 | 14 |
| EPOCH 2 | 83 | 45 | 44 | 30 | 25 | 22 | 12 | 09 | 15 | 07 |
| EPOCH 3 | 107 | 57 | 45 | 30 | 23 | 23 | 22 | 14 | 20 | 12 |
| EPOCH 4 | 118 | 69 | 47 | 31 | 30 | 30 | 30 | 20 | 20 | 14 |
| EPOCH 5 | 79 | 38 | 23 | 25 | 20 | 19 | 07 | 06 | 15 | 06 |
| EPOCH 6 | 79 | 38 | 23 | 25 | 20 | 19 | 07 | 07 | 15 | 06 |
| EPOCH 7 | 106 | 44 | 31 | 28 | 25 | 23 | 19 | 12 | 17 | 07 |
| EPOCH 8 | $\boxed{49}$ | 152 | 80 | 50 | 35 | 26 | 22 | 17 | 26 | 28 |
| EPOCH 9 | 243 | 90 | 45 | 36 | 29 | 23 | 15 | 11 | 19 | 15 |
| EPOCH 10 | 139 | 66 | 42 | 36 | 30 | 25 | 17 | 14 | 19 | 11 |

AVERAGE IS: 38.04

error!

GROWL
SAMPLE#3

09-03-1997

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 543 | 386 | 172 | 119 | 104 | 100 | 74 | 65 | 87 | 44 |
| EPOCH 2 | 749 | 627 | 454 | 198 | 188 | 175 | 201 | 163 | 130 | 79 |
| EPOCH 3 | 726 | 573 | 281 | 156 | 140 | 105 | 70 | 83 | 84 | 56 |
| EPOCH 4 | 323 | 170 | 106 | 110 | 9347 | 80 | 31 | 25 | 68 | 28 |
| EPOCH 5 | 377 | 367 | 235 | 127 | 101 | 86 | 41 | 35 | 71 | 33 |
| EPOCH 6 | 442 | 372 | 257 | 130 | 137 | 104 | 107 | 99 | 85 | 41 |
| EPOCH 7 | 459 | 383 | 289 | 130 | 128 | 96 | 74 | 65 | 75 | 39 |
| EPOCH 8 | 511 | 433 | 291 | 141 | 137 | 102 | 101 | 69 | 75 | 37 |
| EPOCH 9 | 539 | 603 | 365 | 157 | 197 | 119 | 192 | 124 | 79 | 49 |
| EPOCH 10 | 528 | 622 | 452 | 164 | 153 | 165 | 257 | 208 | 115 | 71 |

NORMALIZED PARAMETERS

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 103 | 74 | 32 | 22 | 19 | 19 | 13 | 12 | 16 | 07 |
| EPOCH 2 | 144 | 120 | 87 | 38 | 35 | 32 | 38 | 30 | 24 | 15 |
| EPOCH 3 | 139 | 110 | 53 | 29 | 26 | 20 | 12 | 08 | 15 | 10 |
| EPOCH 4 | 62 | 32 | 20 | 20 | 16 | 15 | 05 | 03 | 12 | 05 |
| EPOCH 5 | 72 | 70 | 44 | 24 | 19 | 16 | 07 | 06 | 12 | 06 |
| EPOCH 6 | 84 | 70 | 49 | 24 | 25 | 20 | 20 | 19 | 15 | 07 |
| EPOCH 7 | 88 | 73 | 55 | 24 | 24 | 17 | 13 | 12 | 13 | 06 |
| EPOCH 8 | 98 | 83 | 55 | 26 | 25 | 19 | 19 | 12 | 13 | 06 |
| EPOCH 9 | 103 | 116 | 69 | 30 | 38 | 22 | 36 | 22 | 15 | 08 |
| EPOCH 10 | 101 | 119 | 87 | 31 | 29 | 31 | 49 | 39 | 21 | 12 |

AVERAGE IS: 37.6

EPOCH 9 522 09-03-1997

GROWL
SAMPLE 4
≃660 ON
TAPE

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 461 | 398 | 281 | 131 | 145 | 101 | 110 | 100 | 74 | 37 |
| EPOCH 2 | 468 | 403 | 291 | 128 | 119 | 94 | 91 | 75 | 72 | 36 |
| EPOCH 3 | 501 | 445 | 282 | 144 | 151 | 104 | 91 | 62 | 73 | 36 |
| EPOCH 4 | 554 | 676 | 427 | 167 | 191 | 138 | 262 | 151 | 85 | 58 |
| EPOCH 5 | 502 | 535 | 391 | 152 | 153 | 145 | 205 | 171 | 109 | 65 |
| EPOCH 6 | 347 | 195 | 191 | 126 | 107 | 96 | 57 | 39 | 71 | 35 |
| EPOCH 7 | 448 | 240 | 206 | 136 | 101 | 98 | 97 | 64 | 87 | 54 |
| EPOCH 8 | 494 | 296 | 207 | 134 | -530 | 117 | 128 | 82 | 92 | 57 |
| EPOCH 9 | 322 | 159 | 104 | 109 | 90 | 80 | 37 | 26 | 68 | 26 |
| EPOCH 10 | 326 | 158 | 101 | 109 | 86 | 80 | 38 | 33 | 69 | 28 |

NORMALIZED PARAMETERS

| FREQ | 250 | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| EPOCH 1 | 106 | 91 | 63 | 30 | 33 | 22 | 24 | 22 | 16 | 07 |
| EPOCH 2 | 107 | 92 | 66 | 28 | 27 | 21 | 19 | 16 | 16 | 07 |
| EPOCH 3 | 115 | 101 | 65 | 33 | 34 | 22 | 21 | 13 | 16 | 07 |
| EPOCH 4 | 127 | 156 | 98 | 38 | 44 | 31 | 60 | 34 | 19 | 12 |
| EPOCH 5 | 115 | 123 | 89 | 34 | 34 | 33 | 47 | 39 | 24 | 15 |
| EPOCH 6 | 79 | 44 | 44 | 28 | 24 | 21 | 12 | 09 | 15 | 07 |
| EPOCH 7 | 103 | 54 | 47 | 30 | 22 | 22 | 21 | 13 | 19 | 12 |
| EPOCH 8 | 114 | 68 | 47 | 30 | 24 | 25 | 28 | 18 | 21 | 12 |
| EPOCH 9 | 74 | 36 | 22 | 24 | 19 | 18 | 07 | 06 | 15 | 06 |
| EPOCH 10 | 74 | 36 | 22 | 24 | 19 | 18 | 07 | 07 | 15 | 06 |

AVERAGE IS: 38.8

**Enclosure 5**
**Article Presented at NASA Technology 2007 Conference**

# MINIATURE LOW POWER DIGITAL AUDIO CAPTURE AND IDENTIFICATION SYSTEM


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We report here on the development of a small low power Digital Audio Capture and Identification System (DACIS) for the automatic identification of animal calls supported by the Strategic Environmental Research and Development Program (SERDP). The system is light enough and low power enough to be attached to larger birds so that the bird can act as a sentinel animal for its own environment. The system is designed to be used with a Global Positioning System (GPS) and Argos Platform Transmitter Terminal (PTT) which will allow accurate location fixes and telemetry of data via satellite. After capture and identification, the time and location of identified sounds are periodically transmitted up to the Argos satellite for relay to the earth.


## INTRODUCTION

In 1981 the Bird-borne program was initiated at the Johns Hopkins University, Applied Physics Laboratory (APL) under U.S. Army funding, to develop a capability to locate (i.e., track) and monitor small highly mobile organisms on a local, regional and global scale. Initially, the program focused on the development of small Platform Transmitter Terminals (PTTs) to be tracked via the French-U.S. Argos satellite system. Since the inception of the program, miniaturization has led to the fielding of transmitters that weigh less than one ounce and are capable of interfacing with an array of sensors.

The primary objective of the Bird-borne and the Remote Environmental Sensing Technology (REST) program (follow-up initiated in 1991) has been to develop a system for the remote tracking and monitoring of free ranging organisms that pose especially difficult field problems for study. Biotelemetry can be used to collect information from the environment surrounding the animal (temperature, humidity, altitude) as well as behavioral and physiological parameters (motion, core temperature and heart rate) of the organism. Biotelemetry has enabled scientists to accurately study behavior, home range, and habitat use of wildlife for basic research and the development of management plans for conservation.

However, for studies of free ranging organisms that travel long distances over extended periods and frequent inaccessible habitats due to geographic or boundary restrictions, such as

military installations, space-based tracking and monitoring systems are advantageous. Remote tracking and monitoring systems can support effective study of these organisms and aid in identifying their range and critical habitat requirements for breeding, migration and wintering.

The planned uses for the acoustic system are to identify the prey on which predatory animals are feeding and identification of known calls of the animal on which the unit is mounted to identify behaviors correlated with those sounds.. While the identification of prey is a desirable goal, it was felt that the number of targets for identification would be too large for a proof of concept. Therefore, the present system is focusing on the latter.

The DOD has established requirements for environmental research, technology development and land management and supports a variety of programs such as Legacy and the Strategic Environmental Research and Development Program (SERDP). Biological studies designed to evaluate effects of military land use on natural resources pose unique and difficult problems because collecting biological data during military activities is required. Advanced technologies that allow remote tracking and monitoring of wildlife can alleviate many of these conflicts yet provide comprehensive data.

## TECHNOLOGY DEVELOPMENT

### Initial Birdborne Development

The Bird-borne effort to develop a space based tracking and monitoring capability started with a study to evaluate the critical engineering paths to build a satellite received transmitter to be used on free ranging birds. Requirements for the development of the first prototype satellite transmitter were, 1) identify a space based system for transmitter development, 2) develop a PTT under 200 grams, 3) allow for 270 days of operation, and 4) accommodate environmental, behavioral, and physiological sensors.

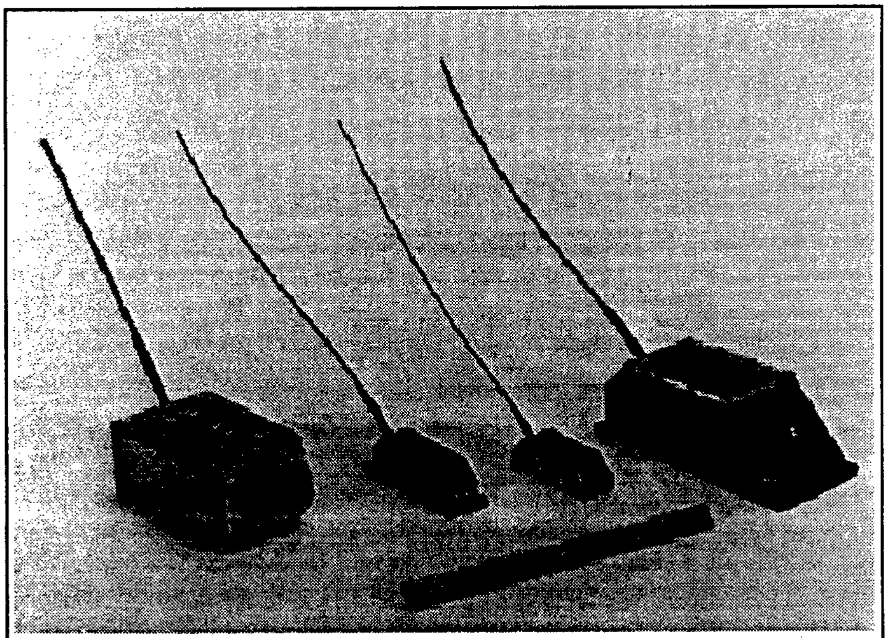

Figure 1: From Left to Right: Original 200 g Argos PTT, 30 and 20 g Nano PTTs and prototype solar powered GPS/PTT

The French operated Argos System fielded in the 1970s proved to be the basis for the development of a bird borne transmitter. The Argos system consists of receivers on the Tyros N series of National Oceanic and Atmospheric Administration (NOAA) satellites positioned in low (850 km) polar orbits. The PTTs weighed a kilogram or more and operated with

primary batteries. The PTTs are positioned based on the Doppler shift, which is dependent on a highly stable frequency transmission at 104.6 megahertz.

The initial bird borne PTT had to be relatively small (<200g), to avoid adversely affecting bird flight. System Argos required PTTs to transmit a minimum of 1.0 watt. To meet this power requirement for transmission for 270 days required 500 grams of primary batteries which exceeded by more than a factor of 2 the maximum allowed mass. Therefore, we initially met this power requirement by using a solar array with rechargeable Ni/Cad batteries. This power a pack allowed for tracking duration of nearly 3 years.

During the past 15 years the electronics in the satellite transmitter have been continually miniaturized and provided new capabilities through the integration of microprocessors and mini-computers as shown in Figure 1. The newest experimental bird borne transmitters weigh 20 grams, which includes 3.5 grams of electronics, an 8 gram battery and the remainder in the container. The transmitter can interface with a variety of sensors to collect information from the environment surrounding the organism as well as collecting behavioral data. Many researchers are now applying PTTs to the study of birds [1] as well as other wide-ranging animals [2].

## DIGITAL AUDIO CAPTURE AND IDENTIFICATION SYSTEM

There remain, however, many questions for research and important conservation issues that need to be addressed in a timely, effective manner, and would benefit from additional development of technology. We report here on the development of a bird borne transmitter that will incorporate a Digital Audio Capture and Identification System (DACIS) that will assist in the interpretation of acoustical information to link time and location to discrete animal behaviors. The initial goals of this system are to analyze and time tag 5 distinct animal sounds from the same species or different species and transmit that data, along with the location at which the call was heard, to the Argos satellite.

Acoustic analysis of various bird calls was performed at APL by producing "waterfall" plots. These show intensity of sound as a function of frequency and time. Plots of several species appear to indicate that a system which prepares a course version of these plots and compares them to a known template will be able to identify different species or different calls of the same species.

### System Hardware

The block diagram of the entire electronics system of the digital audio capture and control circuit is shown in Figure 2. An audio trigger, which consists of a micropower operational amplifier and voltage comparator is always on and listening to the environment. When a preset threshold is detected, the microprocessor is turned on to start the digital recording. The design of the digital audio capture circuit centers on an MC68HC811 micro controller. This device was chosen because it has several system components on a single chip and small size and weight are critical in this system's design. The subsystems of the micro controller are the internal universal asynchronous receiver transmitter (UART), the internal timer, internal Read Only Memory (RAM), Electrically Erasable Programmable Read Only Memory (EEPROM), and an 8-bit Analog to Digital (A/D) converter. The A/D converter is used to sample the amplified signal

from the electret microphone. The audio sample is then immediately stored in memory for future transmission.

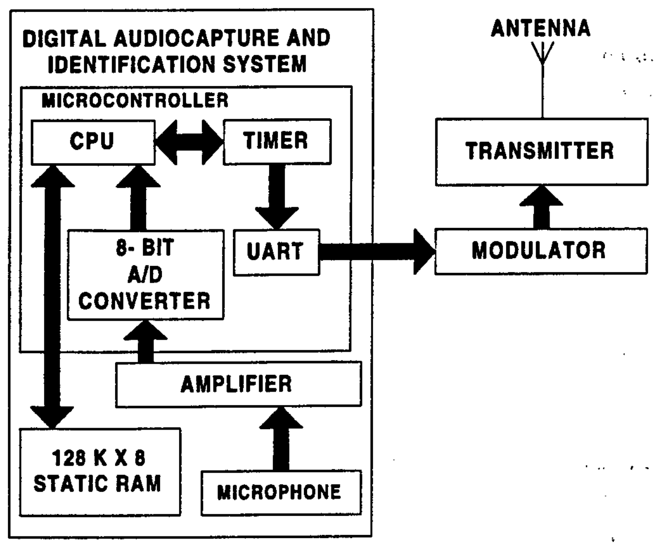


**Figure 2: DACIS Block Diagram**

The MC68HC811, which is an 8 bit micro controller, can only directly address 64K bytes of memory space. Therefore, page mode addressing is implemented using a separate output bit to control the highest address line (A16) of the memory. If more than 128K of memory is required in future versions, new circuitry will be added to control the chip select pins of the memory chip to avoid data bus clashes. There are enough spare gates and microprocessor output pins present on the existing design to increase memory to 512K bytes if desired.

The initial memory configuration, which used two 32 Kbyte memory chips was replaced with a single S-MOS systems 128K byte memory chip. The sampling rate, which can be easily changed in software, was set at 6,000 samples per second to yield reasonable quality audio playback. Initial experiments were conducted with a sampling rate of 2,700 samples per second and proved to yield marginal results for the intended system use. There is a direct trade off between sampling rate and total record time. At 6,000 samples per second and using 128K (actually 131,072 bytes) less 4,096 bytes for EEPROM (and the image of EEPROM in upper memory which is inaccessible in the present implementation), the total record time available is 126,976/6,000 ≈ 21.2 seconds. Presently, only 5 seconds is recorded after each triggering event.

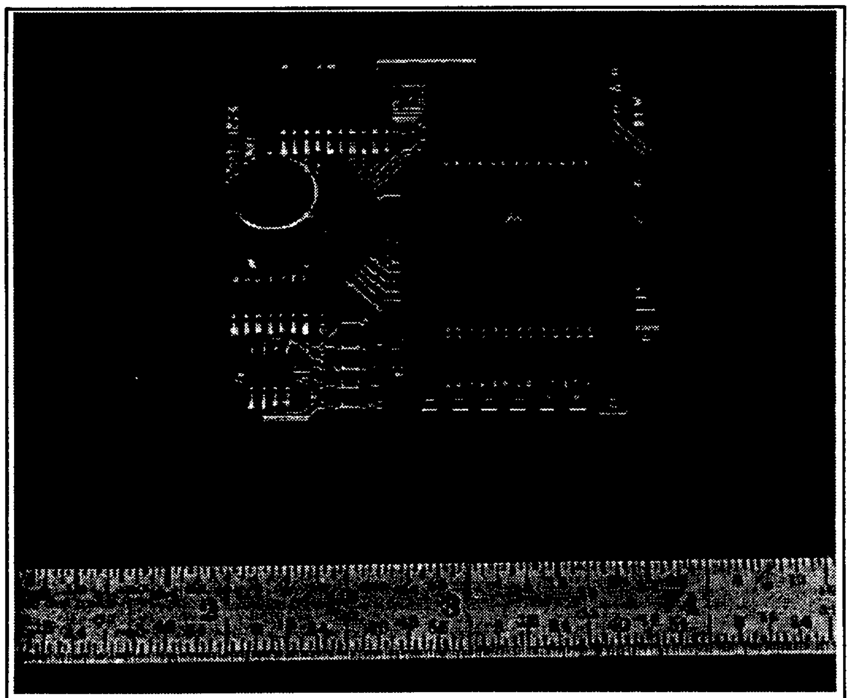

Figure 3: Prototype DACIS Board Showing Processor, RAM and other components

The microprocessor's on-chip UART is used to generate the serial data stream during transmission. The data rate is programma-

ble and has been set to 9,600 bits per second due to requirements of the prototype modulator. The data rate is not infinitely flexible in that the rate is obtained from selectable divide ratios of the microprocessor's clock. The present data format is 8 data bits per word with one start bit, one stop bit, and no parity bit. Additionally, a 74HC4024 counter is used to divide the microprocessor clock by 8 to obtain a 153.6 KHz 50% duty cycle square wave which is 16 times the data rate. This signal is required by the modulator. Lastly, during transmission, a line called transmit is brought low to activate the transmitter. This line activates the transmitter approximately 200 msec before the data starts to allow the transmitter to stabilize. This portion of the system will also serve as the control for future features such as control of a Global Positioning System (GPS) receiver. The microprocessor will then reformat the data and transmit it through the Argos satellite.

All components used in the design are available in surface mount packages. The prototype board is shown in close up in Figure 3. The board measures approximately 2" by 2", weighs about 15 grams, and has a socket for the CPU for test purposes only. A slightly smaller version has been designed without the socket for later testing

## SOFTWARE

A flow chart of the signal processing is shown in Figure 4. All of the software for the system was written in 6800 series assembly language. After power up, the initial section of code simply initializes the timer counter, baud rate resister, A/D converter and I/O pins. The audio capture portion of the software controls the internal A/D converter and stores each sample in RAM. The timing of audio sampling is controlled by interrupts from the internal timer. After all memory is filled, the program stops capturing audio and starts to process the recorded data.

The processing starts by implementing a digital 23 stage FIR (finite impulse response) filter on ten bands centered form 250 Hz to 2500 Hz in 250 Hz evenly spaced increments. The total recording of 5 seconds is divided into 10 epochs of 0.5 seconds each and the ten filters are performed on each of the ten epochs to yield 100 time/frequency parameters. This is a crude representation of the waterfall plot. The parameters are then normalized to account for differences in volume level which may disturb the pattern match.

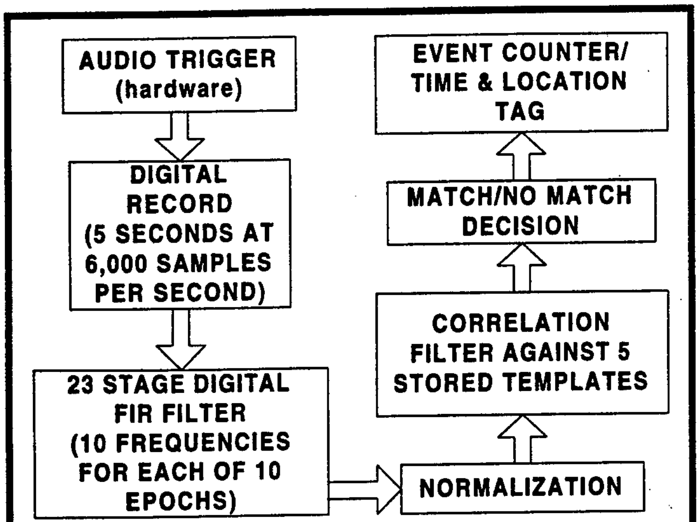


**FIGURE 4: Signal Flow Diagram**

The final processing stage is to match the 100 parameters against the 5 stored templates and the do the threshold detection. These two critical stages are currently under development and testing using wolf calls. The positively identified call information, along with the time and location, will be stored for later transmission. The exact scenario by which transmission will be started has not yet been determined. The possibilities include internal timer activation, reception of a transmitted signal to the animal mounted unit or some sort of proximity activation from a small device placed in or near the animals habitat. The last method has the advantage of allowing the receiver to be near the free ranging animal also so that the transmission distance is short. Presently, if the entire contents of the memory are sent at 9,600 baud, the total transmit time is about 132 seconds.

<u>Global Positioning System Qualified Argos PTT</u>

The Argos system is capable of giving locations to within ±150m anywhere on the surface of the earth but locations obtained from tiny low power (100mW) ARGOS beacons, mounted on the backs of birds often give locations in the range of ±2 km of the birds true locations. To achieve the highest grade Argos location at least 4 messages have to be received by the satellite over a period exceeding 420 seconds. The availability of small commercial GPS receiver modules have now made it possible to combine such a receiver with an Argos transmitter and field a package small enough to be carried by a goose size bird. By scheduling the collection of GPS locations throughout the day and storing these positions for later transmission via Argos as many as 20 GPS positions ( ±20 m) can be transmitted to the user in a single Argos message.

An Argos/GPS package, under development by Microwave Telemetry Inc., incorporates a commercially available GPS receiver, a microcontroller based data logger and a Microwave Telemetry NANO PTT. The data logger controls the GPS receiver and the collection of GPS data which is dependent on power availability from the solar charged power source. The data logger then sequences data transfer to the NANO PTT at times favorable to satellite availability. The prototype unit is now undergoing laboratory testing and weighs less than 200 grams.

## DISCUSSION

The technology we have described is designed for use on free ranging animals to provide data on their locations, behavior, and environment. A GPS receiver, when integrated with an Argos PTT, will provide more accurate location data that can be collected at pre-designated

times. The Argos system is dependent upon collecting frequency data on the PTT signal transmission to calculate a single time dependent location. With the use of a minicomputer integrated into the unit GPS positions can be collected according to a programmed schedule. This will increase our ability to locate free ranging organisms, and derive important facts regarding range and habitat use. With enhanced accuracy and greater numbers of locations, home range estimations, programs, and Geographic Information Systems can be used more effectively to relate animal movements to jurisdiction boundaries, habitat, and land use activity maps.

Animal sound identification data, in combination with time and location, will provide additional information relevant to natural resources. For example, the DACIS is designed to recognize animal vocalizations, thus allowing evaluation of animal behaviors and specific activities. By locating exact animal behaviors and linking them to specific habitat within the range of the organism valuable information can be collected on relationships among animals and micro-habitat components of their range. The real time and near real time components of new telemetry will allow more complete study of animal responses to a wide range of ecological variables. Time coded information on location, heading, altitude, speed, ambient temperature, humidity and other sensor data, can be displayed and analyzed relative to other geographically linked features such as geomorphology, ecological community, meteorology, and land use activities. Free ranging organisms tagged with animal track and monitor units act as a sentinel in the population. These sentinel individuals either moving alone or in herds or flocks, can reflect the activities of many organisms and enhance the biological data base dramatically.

Discussions with commercial companies have not yet identified any willing to fund the development of this system. Some have, however, indicated an interest in fabricating the unit after the proof of concept has been completed. A system which automatically trains the DACIS unit from animal sound recordings will likely be necessary to commercialize this unit. Presently, the setting of the 100 template parameters is a labor intensive task.

The use of a stand-off system to monitor and collect pertinent environmental data can be used very effectively in the evaluation of a variety of issues pertinent to many human activities. Noise effects on people as well as wildlife pose a significant problem in many areas and require a significant investment in time and money to resolve. Sensors capable of measuring environmental noise at the organism are in place and being used by the U.S. Air Force to monitor jet aircraft noise and by the Army to evaluate single event noises associated with weapons testing and training. The DOD is developing the capability to monitor the level of noise at the organism and the behavioral response to the event.

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